COMBUSTION

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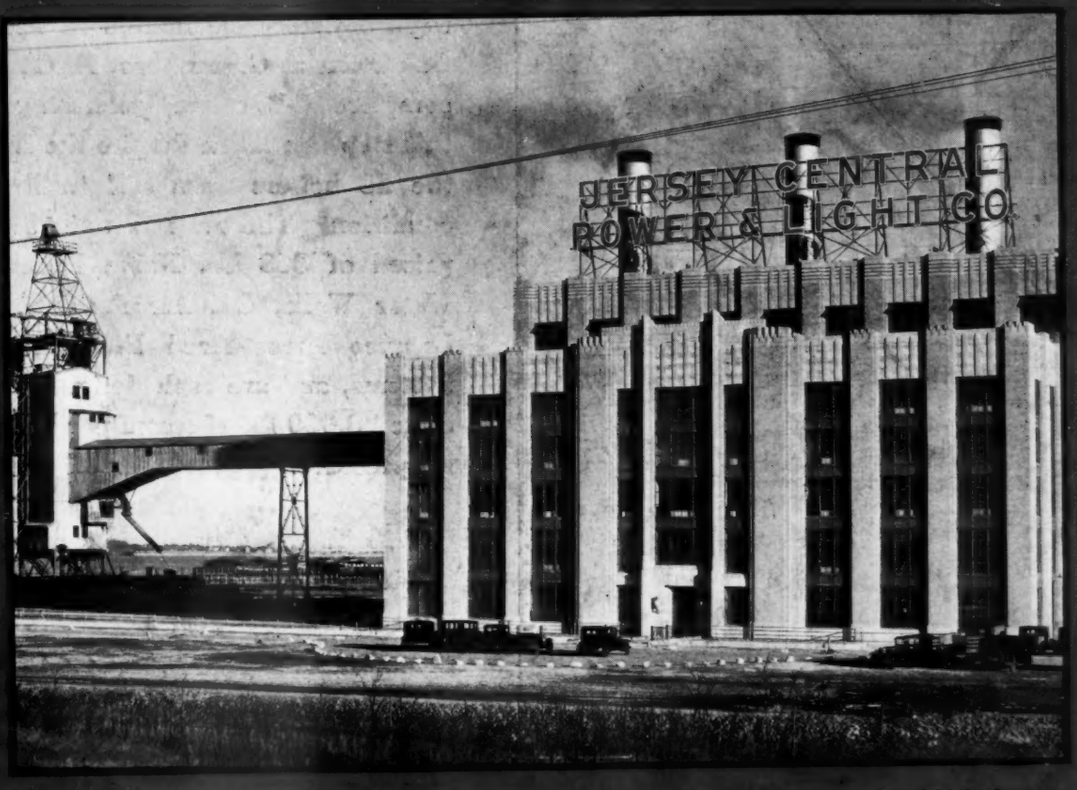


South Amboy Station, Jersey Central Power and Light Company

TREATMENT OF FEEDWATER FOR HIGH PRESSURE BOILERS

By C. E. Joos

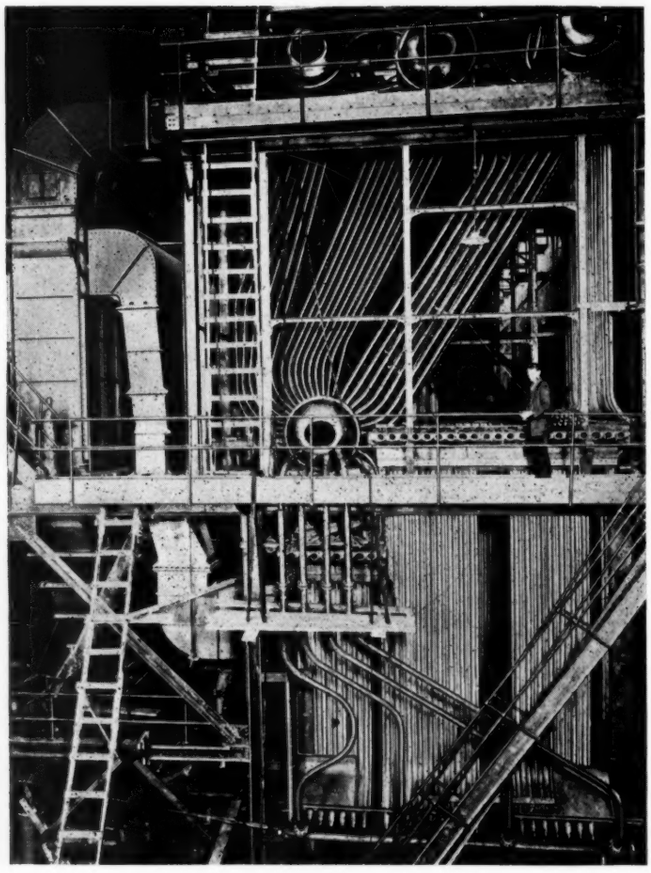
PATENTS

By George Ramsey

Other Articles in This Issue By

JOSEPH H. KEENAN • J. G. MINGLE • DAVID BROWNLIE • R. C. DENNY

Why 28 BOILERS *in first class condition* WERE REPLACED



View of one of two new units in course of erection.

Old boiler room showing boilers which were replaced.

WHEN the Proximity Manufacturing Company realized the extent of the economies possible through replacing 28 water-tube boilers in its White Oak Plant at Greensboro, N. C., with 2 complete C-E steam generating units, this step was taken despite the fact that the 28 boilers were still in first-class condition. The two new units are comprised of 863 hp. Heine Boilers, C-E Water Walls, C-E Air Preheaters and Lopulco Direct-Fired Pulverized Fuel Systems, and are each designed to generate 90,000 lb. of steam per hr. at 445 lb. pressure.

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Mr. J. E. Hardin, General Manager of the Proximity Manufacturing Company, recently made the following statement: "The results obtained from the new plant proved conclusively that it was expedient for the mill to sell as junk, equipment in first-class mechanical condition."

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200 Madison Avenue, New York

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Green Chain Grate Stoker
C-E Multiple Retort Stoker
Type E Underfeed Stoker
C-E Stoker Units (for small industrial and heating boilers)

PULVERIZED FUEL SYSTEMS
Lopulco Storage System
Lopulco Direct Fired System

MISCELLANEOUS
Raymond Pulverizing Mills
C-E Water-Cooled Furnace
C-E Air Preheaters
C-E Economizers
C-E Ash Conveyors
C-E Ash Hopper

CATALOGS ON ANY OF THESE PRODUCTS WILL BE SENT UPON REQUEST

COMBUSTION

VOLUME FOUR • NUMBER TWO

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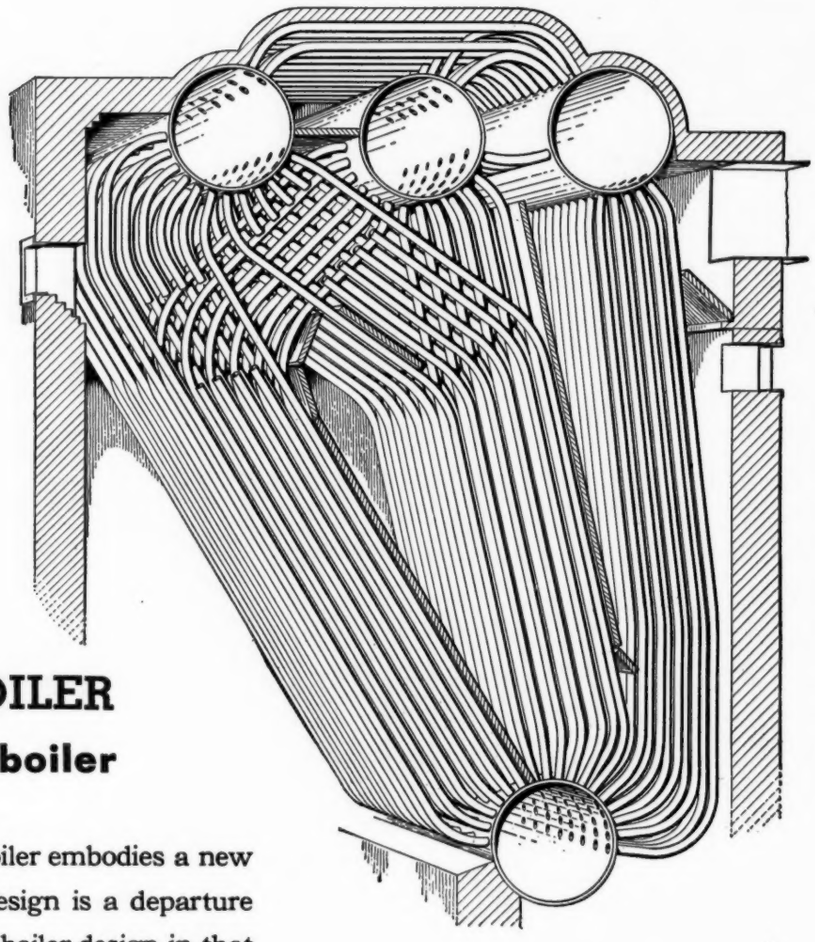

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ANNOUNCEMENT

JOSEPH H. KEENAN

COMBUSTION takes much pleasure in announcing that arrangements have been made with Joseph H. Keenan, author of the recently published A. S. M. E. Steam Tables, for a series of short articles or commentaries on important aspects of engineering research and development. The first of these articles appears in this issue.

While the scope of Professor Keenan's writing will not be closely limited, he will, for the most part, confine himself to the broader aspects of steam research, thermodynamics, etc. For example, he will deal with questions such as, "The Heat Unit", "What is Heat?", "What is Availability?", "What is Entropy?", "Total Heat or Enthalpy." He will endeavor to bring the present-day conception of these terms into the realm of plain words, a sphere that some of them have not heretofore occupied even in the minds of fairly well-informed engineers.

Although Professor Keenan's work is well known to those who have followed developments of recent years in the field of steam research, we feel that many of our readers will appreciate knowing more about him. Briefly, then, he was graduated from Massachusetts Institute of Technology in 1922 in the course of Naval Architecture and Marine Engineering. From then until 1928 he was employed by the General Electric Company doing research and development work in connection with steam turbine design. During this period he was identified with that stage of turbine development which produced the first 1000 lb. per sq. in. turbines, the first resuperheating turbines and the huge 208,000 kw. machine for the State Line Generating Company. Also, during this period he began, in association with Dr. Harvey N. Davis, the development of a preliminary steam chart for high pressures as the first organization into useful form of the current American steam research program. This was published in 1926. In 1927, after the completion of the first set of specific volume measurements by Keyes and Smith, he began the development of a complete steam table extending beyond the critical point. This was published by the A.S.M.E. in 1930.

In 1929 Professor Keenan was one of five American delegates to the first International Steam Tables Conference, held in London. The following year he was a delegate to the second International Steam Tables Conference at Berlin and was a Prime-Movers-Committee delegate to the International Electrotechnical Commission meetings in Scandanavia. Since 1928 he has been engaged in teaching and research at Stevens Institute of Technology.

Professor Keenan combines to a rather rare degree those qualifications which make for notable scientific achievement and the ability to write with clarity and imaginativeness. The latter ability was well exemplified in his editorial "Thermodynamics Grows Up," published in the May, 1931, issue of *Combustion*. In addition to the works mentioned, he is the author of several important papers, the most recent of which, an exposition on the Second Law of Thermodynamics as used in power plant analysis, was presented before the A. S. M. E., in December, 1931.

Combustion is happy to have the privilege of introducing Professor Keenan as a regular contributor to its pages.

Commentary by Joseph H. Keenan

Highlights of Steam Research

STEAM research has had its eras. Regnault, a Frenchman, dominated the first and longest era which stretched from the 1840's to the end of the century. Then came a period of expansion in which no one figure predominated. Between 1900 and 1920 such names as Knoblauch, Henning, and Dieterici in Germany, Callendar and Barnes in England and Canada and A. W. Smith in America lent their luster to the work.

The modern era of steam research dates from 1920 at which time with truly extraordinary spontaneity there sprang up a vigorous activity. It was the work of a group which was as heterogeneous in personality, as single in purpose, and as varied in interpretation as an audience at a symphony concert. Its members ranged as widely in type as in nationality. There was the stolidity and sombreness of the Englishman, Callendar, the ingenious matter-of-factness of our own Osborne, and the forcefulness and fire of Jakob from Berlin. It benefited from the quiet charm of Dr. Knoblauch, the vigorous assertiveness of Dr. Davis, and the incisive vision of Dr. Keyes. It could boast, too, of the gracious and jovial Dr. Havlicek who operates twenty-seven Czechoslovakian coal mines when not too busy with steam research.

Its methods and products were just as various. Osborne built a watchwork mechanism of platinum, silver, gold, and other precious things to measure the thermal properties of water and its vapor. Davis produced a set of unassailable Joule-Thomson coefficients with a boiler from a steam automobile and a tub of oil.

Each era of steam research has proudly exhibited progress. The first proved that the latent heat of steam decreases as the pressure increases and began to trace out vapor pressures to fairly high temperatures. It left us with the belief that the specific heat of superheated steam changes inappreciably with temperature and pressure. The apparent value was about 0.48. Halting though they were, these were the first steps into the unknown complexities of steam.

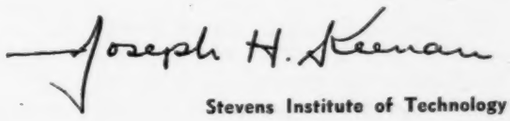
The second era did much more precise and inquisitive investigating in what is now considered a very modest range of pressures. It did quite adequate things with vapor pressures to the critical point. It ventured boldly into that awesome space beyond the saturation line, the superheat region. The Marks and Davis Steam Table crystallized the earlier accomplishments of the era. Using the new throttling and specific heat experiments Davis forced the old Regnault formula for enthalpy* of saturated steam into an honorable retirement. But Marks and Davis found that their experimental resources were practically used up by the time they reached 200 lb. per sq. in.

This era proved, however, that the specific heat of steam does vary with pressure and temperature, though just how far to trust the new Knoblauch measurements was a subject of violent controversy. It also recognized that the enthalpy of saturated steam does not increase indefinitely with pressure but reaches a maximum somewhere. Just where was still matter for argument.

The third era is still in progress, but it has already accomplished much. It has pretty thoroughly justified the Knoblauch specific heat measurements which have by now included a measured value of 4, eight times as large as the unchanging 0.48 of Regnault. It has located the pressure of maximum enthalpy of saturated vapor between 400 and 500 lb. per sq. in. With scientific indifference to difficulty it has stalked into that great unexplored region stretching in longitude from 200 to 4,000 lb. per sq. in. and in latitude from 400 to 1000 deg. fahr. Its various researches have surveyed and resurveyed large areas.

Typical of its international spirit and significant of its progress are the international steam tables conferences which were begun in 1929. A forum for experts in steam research the international conference has established itself as the reconciler of opinions and the arbiter of conclusions concerning the thermodynamic properties of steam. Its chief function is to revise periodically a network of fixed points in the saturated and superheated regions, at each of which there is not only an agreed upon value of volume and of enthalpy, but also an agreed upon tolerance or measure of uncertainty in that value. It has brought all current steam research under searching scrutiny and has annihilated prejudice by putting experts from many nations on a friendly and candid footing.

To the engineer this change is important. He can pick up any one of the three or four steam tables of this new era with assurance that it will give results concordant with the others. Steam tables of 1920 showed a discrepancy of 10 per cent in the enthalpy of saturated steam at 1400 lb. per sq. in. Today the uncertainty is less than 2 per cent. The new era of steam research is quieting the old controversies and producing agreement between steam tables.



Stevens Institute of Technology

* I hope later to expound my prejudices on this point. Enthalpy is what some people have called total heat, others heat content. It is defined as $U + pv$ where U is internal energy and p and v are, as usual, pressure and specific volume.

EDITORIAL

Engineers Should Know More About Patents

THE series of articles on the subject of patents beginning in this issue will merit the attention of all *Combustion's* readers. Those who have had a great deal of experience with patents may find it, in part, elementary, but the series as a whole will give them an increased appreciation of the fundamental nature of patents and the operation of patent law. Those engineers whose knowledge of these things is limited will find Mr. Ramsey's articles highly instructive.

The importance of patents to the engineer cannot be over-emphasized. Every engineer worthy of the name will have ideas in connection with the equipment he designs, manufactures or operates that should be considered from the standpoint of their patentability. The extent to which an engineer is able to improve upon existing designs is an important measure of his ability, and the patent law provides that protection which is due him for the product of his training, experience and originality. In the equipment field, the patent law is the very basis of successful enterprise. No manufacturer would have any incentive to carry on costly development work were it not for the fact that he can reserve to his own organization the fruits of its ingenuity. It is obvious, therefore, that the protection of ideas afforded by patents not only is essential to progress but that without it commercial success in the business of equipment manufacturing would be unattainable.

Yet many manufacturers and their engineers do not take proper advantage of patent protection, primarily because they do not have a sufficient working knowledge of the fundamentals of patent law. The retention of patent counsel is, of course, advisable in all cases, but just as the student who acquires the proper groundwork in his studies can simplify and expedite the work of his teachers and can consequently achieve his objectives better and more quickly, so too the engineer who has some knowledge of patents can save the time of his counsel and give him valuable assistance in his work. For instance, the inventor who has some knowledge of the art of drawing claims, can not only save his attorney's time but is in a better position to determine whether the claims as finally drawn properly interpret and cover his idea. Not infrequently it has happened that claims drawn by competent counsel fail to cover some important point not apprehended by him because the inventor had not appreciated its significance from a patent standpoint and had not properly interpreted it to him.

Combustion seldom publishes articles that are not immediately related to the particular field of engineering it covers, but so convinced are we of the importance of patents to the engineer, regardless of the branch of engineering in which he specializes, that we feel we are rendering a valuable service to our readers in publishing this series on the subject of patents.

Nominees for 1933 Offices of the A.S.M.E.

THE list of candidates for 1933 offices, presented by the Nominating Committee of the American Society of Mechanical Engineers, reveals the underlying reason for the growth and achievement of the Society in the past and for the expectations its members may confidently hold for a continuance of its impressive record. Any organization that can attract men of the caliber represented in this list of nominees is certain to succeed in accomplishing its objectives.

The nominee for office of president is A. A. Potter, Dean of the Schools of Engineering of Purdue University. Vice-Presidential nominees include, J. D. Cunningham, President of the Republic Flow Meters Company; H. V. Coes, Manager, Industrial Department, Ford, Bacon & Davis, Inc., and C. F. Hirshfeld, Chief of the Research Department of the Detroit Edison Company. Nominees for managers are R. L. Sackett, Dean of the School of Engineering at Pennsylvania State College; J. A. Hunter, Professor of Mechanical Engineering at the University of Colorado and Alex D. Bailey, Superintendent of Generating Stations, Commonwealth Edison Company.

Space here does not permit even a brief review of the distinguished records of these men, and this is unnecessary since their success in their various careers and the quality of their services to the Society are well known to its members. Suffice to say that each of them has contributed in large measure to contemporary engineering progress and has enhanced the recognition of engineering as a profession.

The A.S.M.E. has been particularly fortunate in having been able to secure the personal service and interest of such men and the Society as a whole may congratulate itself on the fact that it has had and will continue to have such able leadership and guidance.

While the Society has made a splendid record of achievement, its possibilities for service to its membership and to the profession of engineering are greater today than ever before. Its work should be continued with the active and enthusiastic support of every agency, both individual and corporate, that can assist in accomplishing the important work that lies ahead.

Patents*

By GEORGE RAMSEY

Patent Lawyer

Member A. S. M. E.

The author, Mr. Ramsey, has been requested by the Editor to write a series of articles on Patents from the engineer's standpoint. The present article is the first of the series. Subsequent articles will discuss such subjects as The Patent Office, its structure and mode of functioning; patent claims, their purpose, how they should be constructed, causes of rejection, etc.; interference procedure, appeals and other patent office procedure; assignments and contracts involving the relation of employer and employee; and other aspects of patents that are important to the engineer who seeks to protect his ideas . . . Mr. Ramsey is particularly well qualified to write on these subjects. He was a Member of the Examining Corps of the United States Patent Office from 1905 to 1909 when he left the Patent Office to enter private practice of law specializing in patents. From 1914 to 1916 he was Professor of Patent Law in the Law School of George Washington University, Washington, D. C. In his many years of experience as a patent lawyer he has appeared before all Tribunals in the Patent System. Mr. Ramsey is an engineer and is a member of the A.S.M.E.

Preparation to File An Application

It occasionally happens that a valuable improvement is made by one who is a stranger to the particular art that he has improved. For example, Sir Richard Arkwright, inventor of the spinning jenny, was a barber and Samuel B. F. Morse, the inventor of the telegraph was one of America's foremost portrait painters. Artisans today have become more specialized and more highly trained in their particular branches of industry. Therefore, today the majority of advances in science and industry are being made by engineers, who naturally are interested to profit by their inventions, and it is to this group that the present discourse is particularly directed.

In practicing the engineering profession in any particular line, whether it is automotive, electrical, mechanical, hydraulic or combustion engineering, the engineer meets many problems and he turns over in his mind the most expeditious way to solve these problems. If it is a mechanical or electrical subject, the solution is usually arrived at by numerous sketches. If it is a chemical problem, test tubes and chemical apparatus are probably brought into play, but before the matter is completed it usually is reduced to a chemical equation or formula. The final solution of the problem is new so far as the engineer knows and it serves a useful purpose. Being new and useful are two important attributes to a patentable invention, and after the problem is solved, the first thing which naturally occurs to mind is how can the inventor benefit from this improvement. The answer in almost all cases is that the invention should be patented.

* All rights reserved by the author.

The inventor may not be familiar with patents and may wonder if he has omitted something he should do or has done something he should not do to further the protection of his invention. The first thing he should do is to sign, date, and save all early sketches and written material no matter how crude. Then, the invention should be explained to someone who can understand these sketches and this someone should witness the sketches by signing their name and date thereon. The inventor should write the word "inventor" adjacent his signature and the witness or witnesses should write the name "witness" or "witnesses" adjacent their signature. This not only establishes who is the "inventor," but it also prevents some imaginative "witness" from later claiming the invention as his own.

It is usually advisable to give the first concrete solution a careful circumspect consideration to see if it may be improved or expanded to embrace more useful aspects than were originally conceived. If a better device or composition of matter is arrived at, then this should be sketched up or recorded in more detail and it is desirable that either written description be made or that features on the sketches be designated by written legends, so

there can be no question as to what is represented by the elements in the sketch. This more detailed record of the invention should also be signed, dated, and witnessed. Where it is convenient, it is best to have the sketches witnessed by a notary public. These sketches should be kept even after the patent is granted because if litigation arises, it may be necessary to prove the original date of the invention and these written records are excellent pieces of evidence for establishing this fact.

Patentable Subject-matter

The patent laws provide:—

> "Any person who has invented or discovered any new and useful art, machine, manufacture, or composition of matter, or any new and useful improvements thereof, not known or used by others in this country, before his invention or discovery thereof, and not patented or described in any printed publication in this or any foreign country, before his invention or discovery thereof, or more than two years prior to his application, and not in public use or on sale in this country for more than two years prior to his application, unless the same is proved to have been abandoned, may, upon payment of the fees required by law, and other due proceeding had, obtain a patent therefor."

The words "any person" means a single individual or a group of individuals but does not include a corporation which is often considered in the law as "a person" for certain legal purposes, the obvious reason being that an invention is produced by processes of thought which, of course, can be accomplished only by individuals.

The terms "invented or discovered" are now used substantially synonymously. In the early days of patent law, inventions were sometimes considered as pertaining to mechanical ideas, whereas discoveries pertained to chemical methods and processes. This distinction has, however, disappeared.

The question as to what is an "invention" continuously troubles the Courts and the Patent Office, and no satisfactory definition has been made. The nearest to a definition is the statement of a United States District court that:—

> "Skill of the art is the knowledge of yesterday used to perform the work of today. Invention goes beyond skill of the art."

The invention must be "useful." The word "useful" is used in its broad sense as meaning—not harmful to society. An instrument which could only be used as a burglar tool might be very useful to a criminal but it is harmful to society, and, therefore, is not patentable. A key or pistol may be patentable since it has a legitimate use even though its use may be diverted to a criminal purpose, the presumption being that the device will be used properly.

The patentable inventions are limited to "an art, machine, manufacture, or composition of matter." It, therefore, will appear that not every invention is patentable. It has been held that systems of bookkeeping do not come within the law and are not patentable, although the individual ledger sheets used in the system may be patented, since they are articles of manufacture. It has also been held that the methods of producing anesthesia are, for the same reason, not patentable, although the steps and processes of producing the chemicals or even the chemicals used may be patentable. An "art" includes such inventions as relate to methods of manufacture, processes, mechanical, chemical, electrical, etc., and other inventions relating generally to steps in an art. A "machine" is a mechanical, electrical, or other apparatus for general use as a device. A "manufacture" comprises usually unitary structures such as golf tees, golf balls, baseball bats, ingot molds, pipe holders and other articles of this kind. A "composition of matter" comprises such articles as briquetted fuels, cements, chemical compositions, roofing materials, and other composite materials.

An original inventor may obtain a patent in the United States upon an identical device used abroad, provided he had no knowledge of such foreign device at the time of making his invention and provided the device was "not known or used by others in this country, before his invention or discovery thereof"; also provided that the device is not disclosed in some printed publication which antedates his invention.

"Any printed publication in this or any foreign country" includes printed documents available to the public in any country. If such a document were written in Japanese and existed only in Japan, prior to an inventor's discovery or invention, or two years prior to his application for patent, then any patent granted upon such an invention is invalid. This phase of the patent laws opens an enormous field of search when an important patent gets into litigation.

An inventor who is attempting to improve his invention, and does not abandon it, may obtain a patent even after the invention has been in "use" and on public "sale" in this country provided his application is filed within two years from the date of first public use or sale of his invention.

Design Patents

There is another type of patent provided for by law, namely, design patents. A design patent is one which covers merely shape, form, or ornamentation. The subject-matter may include ornamental objects such as cabinets, bottles, containers, pencils, jewelry, carpets, wall paper, and kindred articles wherein design is the essence of utility. In design patents, the Patent Office now usually allows but a meager specification, for example, the specification for a design on a rug may consist of a single sentence, namely, "The design for a rug as shown in the Figure of the drawings." The Patent Office does not permit broad and narrow claims in design patents. The claim allowed would be simply "I claim:—The design for a rug as shown and described." Design applications are very simple to prepare, but often require great analysis and skill to convince the Patent Office that the design is patentable. The Courts are usually

inclined to hold the claim of a design patent to cover merely the specific design illustrated in the patent, so that proof of infringement becomes difficult, unless the infringer makes a Chinese copy. Design patents have their place in the realm of patent protection, but are by no means as comprehensive in scope as the so-called "utility" patent. They prove most valuable where a manufacturer believes he has a design that will catch the public fancy and wishes to maintain an exclusive appearing article for a limited time. Design patents are also useful in protecting articles which sell on appearance only and have a short time market, like campaign buttons, or a statuette of some passing mode.

Disclosure to Patent Lawyer

Having developed the invention to a point where it seems satisfactory, the inventor may desire to try out the invention in a practical way before going further with it, that is, he may make a working device and make working tests. These tests may lead to further improvements or may confirm an opinion that the device is satisfactory for the purpose intended. These practical tests have the advantage of establishing a "reduction to practice" which is of importance as establishing the actual date of the completed invention. As an alternative, the inventor may immediately present the matter to a patent lawyer with the idea of obtaining patent protection. The term "patent lawyer" is used advisedly because an application for patent is the first layer in the foundation of patent protection which, if the patent is valuable, in most all cases, must be sufficiently strong to stand the severe stress of litigation. It, therefore, seems reasonable to suppose that a patent lawyer, that is, a man who is experienced in Court procedure, should be able to draft the original papers in such manner as to lay a solid foundation which will not crumble in litigation under the attack of brilliant lawyers and skilled experts. It is a relatively easy matter to prepare a patent application that will get by the Patent Office requirements; it is a difficult matter, however, even in a simple case, to draft a patent specification which so clearly defines the invention that no part is omitted and at the same time in carefully chosen words distinguishes the invention from the known art in which it is an improvement. The engaging of the services of a patent lawyer may involve a slightly higher initial expense, but it is better to be safe than sorry. There is no intention to condemn all patent solicitors who are not patent lawyers, since there are very capable solicitors who are more skillful than some patent lawyers, but it is obvious that Court experience is valuable to one preparing an application. It is easy to lay out the shape of a ship on a drafting board, but to build a ship which will stand the most severe storms requires experience.

When the invention is taken up with a patent lawyer, it is best to assume that he knows nothing of the subject-matter even though the invention may be simple. It is better to give him a mass of useless details than through timidity to omit some feature that seems trifling and yet may later prove to be the keystone of the arch.

Preliminary Search

When the attorney thoroughly understands the invention, it is advisable that the attorney be authorized to have a preliminary search made through granted patents to determine if the invention is an entirely new idea or is novel only in some unimportant detail with the broad idea being old. Unless the inventor has an unusually full knowledge of the art which he has improved, he should never rely upon his own opinion as to the novelty of his invention. In the substantially two million patents in the United States Patent Office, there are disclosures on almost every line of human endeavor, from teething rings to adding machines and from frying pans to locomotives. It is of no consequence to suggest that "if the idea had been known it would have been used" because there is many a good idea that has been patented years ago by someone who was unable to exploit the invention or at a time when the invention was out of tune with the art, that is, ahead of the art, and which patent has never come to general public notice. A preliminary search is ordinarily a search through United States patents in the classification to which the device belongs. It should only be considered as a perfunctory search that is by no means exhaustive, but it is usually sufficient for its purpose. A preliminary search is usually made in a few hours, while an exhaustive search might take months to make.

When the search through the Patent Office records is completed, copies of patents most nearly like the invention searched may be obtained from the Patent Office, and the patent lawyer will discuss the disclosure in these copies of patents with his client as to their relation to the client's invention. The client will not be able to obtain a patent for an invention already disclosed by prior patents. [There are exceptions to this general rule, one of which is where a patent was recently filed in the Patent Office and issued quickly after filing without claiming the specific invention which the applicant claims, and where the inventor has embodied his invention in a machine which has been successfully used before the date of his application for patent provided the client's application for patent is filed within two years from the date on which the prior patent issued and provided the client can establish under oath the actual use or completion of his invention before the date when the patent was filed as an application. This is called "swearing back" of a reference.] If there are important distinctions between the disclosures in the copies of patents and the invention, the patent lawyer will point out these distinctions to the client with a statement as to the possible breadth of patent that may be obtained. If the result of the search satisfies the inventor that there is patentable subject-matter which he desires to protect, then it is up to the patent attorney to draft the application.

Application and Claims

The application will comprise formal papers—petition and oath—, drawings (in most cases), a specification and claims. The drawings must be of a standard size, a standard weight Bristol Board of high quality, and preferably of pictorial character, since the drawings are intended for illustrative use rather than for accurate mechanical dimensions. The Patent Office drawings are usually made by draftsmen who are specialists in this work and who are thoroughly familiar with the requirements of the Patent Office. The specification should comprise a complete description of the invention, and in mechanical, electrical, hydraulic or similar cases, it usually comprises a detailed narrative of parts of the device as disclosed on the drawings, and in their operative relation to each other. Federal Judges, who have exclusive jurisdiction of patent cases, are a highly intellectual body of men of keen discernment but they are usually appointed from the Bar of general practitioners and seldom have a scientific training necessary to easily comprehend a technical document, and a Judge may be confused by attempting to read a specification which contains reference numerals referring to a drawing. By the time he has studied out the features of the drawing, he has lost the context of the narrative. Therefore, it is often desirable to preface the detailed description in the specification with a short narrative which explains the invention in its relation to the art and points out the step of improvement which the invention brings into the art. This statement should be concise, of carefully chosen words, and should be a general statement rather than a specific reference to the mechanical details by which the result is accomplished.

There is or should be no mystery in a well written specification. It should be full and complete so that anyone skilled in the art should completely understand the invention, its uses, and how it may be practiced when the specification is read. The specification should not contain laudatory or self praise clauses. It is a description—not an advertisement, but it is of the utmost importance that the original specification and drawings shall clearly set forth all the essential features of the invention. If it is later discovered that some essential feature is omitted, it is just too bad, because such omitted feature cannot be added after the case is filed in the Patent Office. It is also extremely important that the disclosure in the application shall be operative, because if it will not work the patent will be refused if the fault is caught by the Patent Office, or if the Examiner misses the point and it is discovered in Court, the patent will be held void. Even where patent descriptions have been written from actual machines, a hurried or hasty consideration or sketch from which the patent drawings are made has been known to result in omission of important details, the end being that a valuable invention was dedicated to the public because the feature which made the invention valuable was omitted from the specification and drawings. Patent drawings, however, are not working drawings, but are merely for the purpose of illustration. If in a patent drawing, sufficient clearance is not allowed for the parts to operate, this would make an inoperative machine if it were built in strict accordance with the drawings; however, such a discrepancy is not considered as rendering the patent void for inoperativeness. The doctrine of inoperativeness applies more especially to the principle of operation, so that if the gearing of a machine was such that one part should run forward while another would run backward and these motions were essential features of the machine, if the disclosure were such that the motions were not attained, such a device would probably be held to be inoperative. If the invention comprised electric circuits, and the draftsman had made a mistake in drawing the lines representing connected circuits, the device from a practical standpoint, would be inoperative if the drawings were strictly followed. However, in connection with errors of this kind, if they may be cured without making an invention, that is, if the correction is within "the skill of the art," the Patent Office will usually allow corrections. It is clearly within the skill of the electrical art to correctly connect standard apparatus and if the connections are merely wrongly placed on the drawings, and it is obvious that the usual connections are intended, the Patent Office will allow the drawings to be corrected. There are many other types of corrections which can be made. However, if an essential feature of the invention is omitted, which feature would require more than "skill of the art" to be added into the faulty disclosure, then the omission from the original papers is fatal. If possible, a new application should be promptly filed, but occasionally statutory bars such as two years public use, or a two year old publication, arise which prevent the filing of a new application, and the right to a valid patent is thus forever lost.

The real heart of the patent application is numbered paragraphs which follow the description of the invention, which numbered paragraphs are called "claims." These paragraphs comprise short concise statements of a novel portion of the invention defined in accordance with the technical rules of patent law. Each numbered paragraph or in other words, each "claim," must define a patentably different invention from all other claims. It is around these claims that the technical patent procedure both in the Patent Office and in the Courts has grown up, and the attorney should have in mind all of this mass of patent law when drafting the claims to cover the invention. Here again, there is no mystery and the attorney should be able to explain the "claims" to the client in such manner that the client will understand at least in a general way what is intended to be covered by the claims in his application.

Requirements in the Oath

After the application has been completed and ready for signature, the question may arise as to

whether the invention is a sole invention of one person or a joint invention of more than one individual. The facts as to this phase of the situation should be fully presented to the attorney who will determine whether the application shall be made out in the name of a sole inventor or joint inventors. It is not unusual for an inventor to request that another individual be joined in the application papers with him because of some agreement whereby the second party is to have an interest in the invention. Under these conditions, the second party should never join in executing the application. The law covering this feature specifies that: "The applicant shall make oath that he does believe himself to be the original and first inventor or discoverer of the art, machine, manufacture, composition, or improvement for which he solicits a patent."

The oath forming a part of the application, therefore, must be sworn to by "the inventor." Now the inventor may be one individual or a group of individuals, but one who is merely an owner of an interest and who had nothing to do with conceiving the idea of the invention is in no sense any part of "the inventor." Where the work of a group of individuals results in an invention, the members of the group probably are joint inventors. If, however, the ideas of the group came from one man and the other members merely supplied the well known "skill of the art" in order to carry out these ideas, in that case, the invention is a sole invention of the originator, and not a joint invention of the group. If there is any doubt on the question, it is desirable that all parties involved shall sign as joint inventors. It is possible to save an application or patent where parties have signed as joint inventors when, in legal effect, the invention was really a sole invention, on the theory that the group included "the inventor" who thus has been brought before the Patent Office and the law is complied with. If an invention is the result of a plurality of individuals' work and is a true joint invention, but the application is taken out in the name of one party alone, and it can be subsequently proven the invention is really a joint invention, any patent on such application would be void, because in the strict sense of the statute, "the inventor" was not before the Patent Office. However, even in this case, the law is not well settled because from the quoted paragraph above, it will be observed that the applicant takes oath "that he does verily believe himself to be the original" etc. In other words, it has been held that the mere fact that the applicant was sincere in his belief was sufficient to justify the requirements of the law. The correct answer to this question, like many others arising in patent law, differs with each particular case, and it is difficult to give a broad legal definition which will meet every possible condition. If the question of joint and sole inventorship arises, all the facts should be presented to a patent lawyer of experience for his opinion as to the best procedure under the circumstances.

The inventor must also state, under oath, "that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof" which means that his invention is new so far as he is aware. The inventor must state "that to the best of his knowledge and belief the invention has not been in public use or on sale in the United States for more than two years prior to his application." This means that the application should be filed within two years after the device has become commercialized in the United States. Individual use, or use under his control to determine the practicability of his invention, is usually held to be "experimental" use, and not public use. There is a famous case of a public road having been used seven years before the application was filed. This use was held to be experimental use, on the ground that it took time to test a road invention. But where a device has been passed out of the control of the inventor for the purpose of a general use, such use has been held to be public use. The leading case on this is where an inventor gave his lady friend a corset stay more than two years before he applied for his patent, and the private personal use of this stay by the lady was held to be "public use," which invalidated the patent. The reasons on which this decision is based are that the gift was outright and unqualified and no inquiries were ever thereafter made as to whether or not the stay was satisfactory.

The inventor further is required to state to his best knowledge and belief that his invention was not "patented or described in any printed publication in any country before his invention or more than two years prior to his application." This means that if it were patented or described in a printed publication before his invention, he would not be the first and original inventor. It also means that if it had been disclosed or described in a printed publication more than two years before his application, even though it was after the date when he actually made his invention, still he could not obtain a valid patent. He must further swear that the invention was not "patented in any foreign country on an application filed by himself or his legal representatives or assigns more than twelve months prior to his application in this country." This statutory requirement is intended to speed up the filing of applications in this country rather than filing them abroad. If an application has been filed abroad more than twelve months before the inventor applies in this country, it is all right providing the patent abroad *has not issued.* If the application is filed more than twelve months and then the patent issues abroad, no valid patent can be obtained in the United States. The oath must also state whether or not foreign applications have been filed and if any have been filed, then the name of the country and the date of filing the application in the country must be specified.

Where an inventor is dead or is adjudged insane after he has completed an invention, but before the application has been executed, the application may be signed by the executor, or administrator of the deceased person; or the guardian, conservator, or

representative of the insane person, in which case the oath shall allege the official relationship of the affiant to the inventor and shall, upon information and belief, state the facts to which the inventor is required to make oath.

While the Patent Office will not accept an application without an oath attached thereto, nevertheless, the Supreme Court of the United States held a patent valid although no oath was found in the file in the Patent Office when this file was examined after the patent had been issued. The Supreme Court decided on the presumption that the requirements of the law had been compiled with and that the absence of the oath was not conclusive proof that no oath had ever been in the case.

All of these requirements in the oath are statutory provisions, which go to the essentials or requirements for a valid patent. The oath contains statements as to many facts which may not be within the inventor's knowledge, so, therefore, the oath merely requires that the inventor shall state that he "believes" and also that "to his best knowledge and belief" the facts he recites are true so far as he knows. However, the oath of an application is not a thing to be considered too lightly. It is a serious matter, and if an inventor deliberately lies as to facts required in the affidavit, he may be charged with perjury. There is at least one case where an individual swore falsely in his oath to an application for patent and he was sent to the penitentiary for having committed the crime of perjury.

Execution of Application

The application, in its completed form, when executed by the inventor, must be signed with the first and last name in full. Middle initials may be used. "Abbreviations" or "nick-names" cannot be used unless they are the inventor's full name; for example, if the inventor's true name is "Jack" or "Tom," he must state in the oath that this is his full name.

Before the application is executed, the inventor must read over the application or at least inspect the application sufficiently to know that it sets forth the inventor's invention or discovery. If the inventor cannot read, he may have the application and claims read to him and he will then execute the application by making his mark, duly witnessed as in case of any other legal documents which he may execute. In any case, however, the application must be inspected. Otherwise, if testimony should later show that the applicant signed without inspecting the case, the Patent Office Rules provide the application "will be stricken from the files."

If executed in the United States, the application must be executed before some person authorized to administer oaths and who is provided with a seal of his office, which must be impressed on the oath. If he has no seal, then his official character must be established by competent evidence.

Any application wherein the oath and the petition have been signed and then any part of the specification written in or filled in thereafter, will be stricken from the files. In other words, every application altered or partly filled out after being executed will be thrown out by the Patent Office if this fact becomes known. It is, therefore, desirable that the application papers comprising the petition, the specification, the claims and the oath shall be ribboned together under a paper seal over which the official seal of the notary public or other officer is impressed. When such ribboned papers are filed in the Patent Office, it is evidence that no change of papers constituting the case could have been made after the case was executed. Where an application is executed abroad, ribboning of the papers is required and the oath must be executed before an officer holding a commission of the United States Government such as a Minister, Consul, Commission agent, etc., or before a notary public whose authority can be proved by a certificate of the diplomatic or consular officer of the United States. Usually applications for United States patents executed in foreign countries are executed before United States Consuls.

The drawings require the applicant's name but under the Power of Attorney usually accompanying the petition, the attorney is empowered to sign the applicant's name on the drawings.

The application is now complete and ready for filing in the Patent Office by being mailed to the Commissioner of Patents, Washington, D. C.

Dr. Webster N. Jones, general superintendent of the processing division, The B. F. Goodrich Company, Akron, Ohio, has resigned, effective August 1st, to become director of engineering of Carnegie Institute of Technology at Pittsburgh.

Dr. Jones joined Goodrich in 1919 as research chemist, and in 1925 he was placed in charge of the production chemical laboratories and the training of young technical men for the company. 1927 he was appointed technical superintendent of the processing division, and the following year became general superintendent of this major division.

In engaging in educational work, Dr. Jones returns to a field in which he has spent ten years of his career, having taught at Purdue University, Harvard University, the University of Maine, the University of Missouri and the University of Montana. His interest in the careers of young men has been an outstanding characteristic and has contributed to his success in industry, as well as in teaching.

The Stephens-Adamson Mfg. Co. manufacturers of conveyor equipment, Aurora, Ill., has established a new branch office at Rochester, with headquarters in the Cutler Building.

F. H. Wisewell, well-known Rochester engineer, has been appointed District Manager, and will be in charge of sales and engineering.

The Performance Characteristics of Centrifugal Boiler Feed Pumps

By
J. G. MINGLE, Indianapolis, Indiana

In this article the author continues and completes his discussion of centrifugal boiler feed pump performance, begun in the July issue. The previous article described the several forms of pump efficiency and capacity and told by equation and chart how to determine these measures of pump performance. The present article deals with the nature of the various curves of pump performance, interpreting the significance of the curve shapes and showing the advantages and disadvantages of particular curve characteristics.

THE characteristics of a centrifugal boiler feed pump are the curves which show the relation between head, capacity, efficiency and horsepower. Fig. 1 shows a typical set of characteristics for a typical boiler feed pump of this type. The head-gallon curve shows the relation between the head developed and the capacity delivered when the unit is operating at a constant speed. The brake-horsepower curve shows the amount of power required to deliver the various amounts of water at the corresponding heads, or in other words, the amount of power transmitted by the driving unit to the pump shaft. The efficiency curve shows the relation of the energy output to the energy input, or the ratio of the water horsepower to the brake horsepower. The point of zero discharge corresponds to the shut-off head, shut-off pressure or point of impending delivery and the point of zero head to wide open delivery.

The head developed by the impellers at the various capacities, on test at constant speed, is the sum of the discharge pressure expressed in pounds per square inch by a pressure gage, plus any static head between the center line of the pump and the gage at the discharge end of the pump, and the vacuum expressed in inches of mercury by a mercury gage, or in pounds per square inch by a vacuum gage, at the suction of the pump plus any static head between the center line of the pump and the gage. The maximum head developed by a centrifugal boiler feed pump is not necessarily the shut-off head. Ordinarily the head-gallon curve rises slightly from shut-off head to a point some distance out and then droops to the wide open delivery point. As the head decreases, the capacity and the brake horsepower increase. This phenomena is called the "head-drop".

Head-gallon curves may be classified into three general groups according to their shape, viz:

1. Falling, drooping or steep characteristic,
2. Rising characteristic,
3. Flat characteristic.

The shape of a head-gallon curve is determined by the design and construction of the impellers.

In a typically steep-falling, head-gallon curve as illustrated by Fig. 2, the head continuously decreases from shut-off to zero as the capacity increases from zero to wide-open delivery, the efficiency curve is practically dome-shaped and the brake-horsepower curve is comparatively flat. This type of characteristic is advantageous to use when the total dynamic head is extremely variable and also when two similar pumps are to operate in parallel. Such a characteristic is conducive to an operation which prevents the pumps from "racing" or "hunting" due to one pump operating at a different point on the head-gallon curve from the other, or prevents one pump from "pushing" the other off the line altogether. This is of great advantage in stations where the capacity of one pump is insufficient to supply the requirements of the boilers at peak loads and it is necessary to operate another in parallel with it. In such a case as this, it is quite important that both pumps deliver as nearly as possible equal amounts of water at the corresponding heads and that the heads also be equal. In other words, the pumps should be identical in construction and have similar head-gallon curves.

The advantage of the practically dome-shaped efficiency curve lies in the fact that the maximum possible efficiency can be obtained under both reduced head and reduced capacity operating conditions due to the fact that the neighborhood of the peak of the curve is relatively flat. Since the highest point on the efficiency curve is located at the point corresponding to the normal head and capacity for which the pump is designed, it is advantageous from a power consumption standpoint to maintain this efficiency as high as possible when the capacity and head vary moderately from these normal conditions. The comparatively flat top of such an efficiency curve results in only a slight drop in efficiency with a moderate variation from the normal operating conditions.

The advantage of a comparatively flat brake

horsepower curve is that the driving unit is continuously operating at its maximum rated capacity and efficiency regardless of where the pump is operating on the head-gallon curve. The stock size of the motor or turbine selected to drive the pump should correspond with the brake horsepower involved at the normal head and capacity and ordinarily it is not necessary to select the next larger size to accommodate the slightly increased brake horsepower due to the reduced head conditions.

In a typically rising head-gallon curve as illustrated by Fig. 3, the curve rises from shut-off head to a maximum point at a capacity equal to approximately one-fourth the wide open delivery after which it drops rather abruptly, the efficiency curve is also practically dome-shaped, and the brake horsepower curve is comparatively steep but not as steep as that for a flat characteristic. A rising characteristic insures a relatively low shut-off head and a correspondingly low initial point on the brake horsepower curve and is particularly advantageous on operation at low capacities as, for example, when the boilers are in readiness waiting to be put on the line and also when they are at or near the pop-off stage, during which time, in both cases, they require very little water, and also when the load is extremely variable and the boilers operate for comparatively long periods of time at a low rating when comparatively small quantities of water are required. This type of curve is also advantageous when a considerable portion of the total dynamic head is composed of friction head and in installations which would otherwise involve a considerable amount of throttling for small discharges since the pump, in effect, automatically throttles itself due to its rising characteristic.

In a typically flat head-gallon curve, as illustrated by Fig. 4, the head remains practically constant from shut-off to zero head as the capacity increases from impending to wide-open delivery, the efficiency curve is more egg-shaped than dome-shaped and the brake-horsepower curve is comparatively steep. A characteristic of this type is

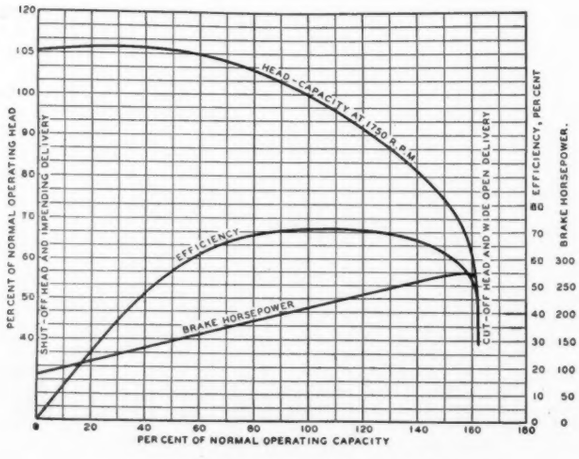


Fig. 1—Typical centrifugal boiler feed pump performance characteristics.

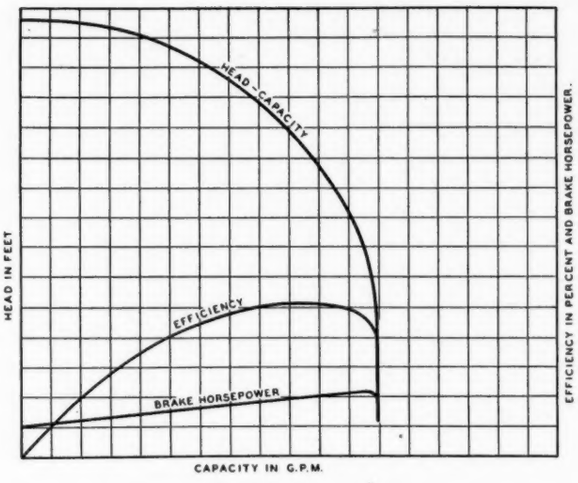


Fig. 2—Typical falling characteristic of centrifugal boiler feed pump.

advantageous in installations where the total dynamic head is practically constant, where a variable capacity with a constant head is desired and where two pumps are to operate in series, but is not suited for parallel operation. A flat head-gallon curve is advantageous in stations where the boiler rating is extremely variable but the pressure practically constant. In such cases, one pump will ordinarily take care of the boilers when they operate at their normal rating, and two pumps operating in series when the rating is increased. The same results can be accomplished with a pump with a rising or steep-falling head-gallon curve but, for normal boiler ratings, at a reduced capacity, a greatly increased head, a reduced efficiency and an increased brake horsepower, whereas with a flat head-gallon curve, the head of course remains constant, the capacity varies as required, the efficiency remains practically constant over a moderate variation and the brake horsepower is decreased if it varies at all. A flat head-gallon curve is of immense advantage in installations where the pump will operate at or near shut-off for several minutes at a time since the brake horsepower involved is relatively low at shut-off due to the steep brake-horsepower curve. This type of curve is not suited for over-capacity conditions since the head-gallon, efficiency and brake-horsepower curves drop off rather abruptly with the result that operation would be unsatisfactory. This type of curve is also not suited for parallel operation since, due to its flatness, the two pumps will tend to "race" or "hunt" or, in other words, deliver unequal amounts of water at the same interval. A flat characteristic, however, is well suited for series operation. For example: with two four-stage pumps operating in series against 800 ft. total head, the lower pressure pump will develop a head of 400 ft., the first, or suction, impeller receiving the water at suction pressure and raising the head to 100 ft. at which head the water is discharged into the second impeller which raises the head to 200 ft. by adding another 100 ft. and so on until the fourth impeller raises the head to

400 ft. at which head the water is discharged into the suction impeller of the higher pressure pump and this and the succeeding impellers of this pump raise the head successively until the last impeller raises the head to 800 ft., the final head, or pressure.

The egg-shaped efficiency curve results in a steep brake-horsepower curve which in turn produces a relatively low brake requirement at shut-off head. With this type of efficiency curve, it is possible to locate the maximum, highest point at practically any desired capacity on the head-gallon curve by simply reducing the over-capacity.

The advantage of a steep, brake-horsepower curve lies in the fact that the pump will operate at the lowest possible horsepower under reduced capacity conditions, especially at or near shut-off. Due to the fact that the horsepower curve still rises beyond the normal operating point, care should be taken that the driving unit is of sufficient size to take care of the conditions involved at all reduced head and increased capacity conditions.

Fig. 5 shows a typical set of characteristics which include a drooping, more commonly called an "unloading", brake-horsepower curve. This curve gradually rises from shut-off head and impending delivery until a maximum is reached in the neighborhood of the normal head and capacity conditions and also the maximum efficiency of the pump after which it gradually (not abruptly) droops to zero head and wide-open delivery. This unloading curve may be attained in several ways, viz: by throttling at the eye of the impeller thereby producing cavitation, by confining the exit angle of the impellers between 10 and 17 deg., or by means of an impeller narrow in width which accommodates the smaller capacities by reducing the eddy losses to a minimum and also induces a relatively abrupt drop in head at the higher capacities due to friction losses within the impeller passageways. The principal advantages of an unloading brake-horsepower curve are: decreased horsepower for reduced head and increased capacity conditions—a condition the opposite of the ordinary

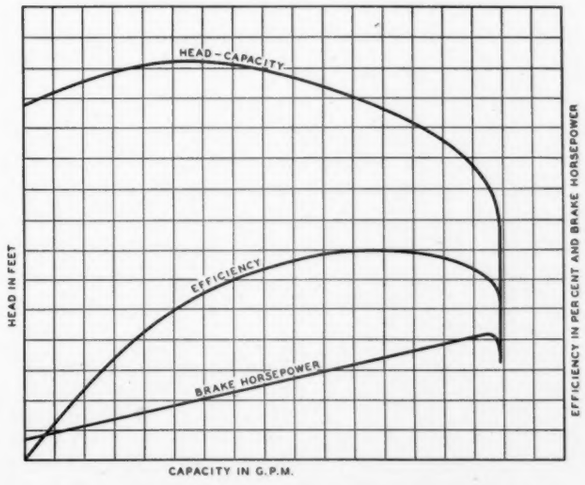


Fig. 3—Typical rising characteristic of centrifugal boiler feed pump.

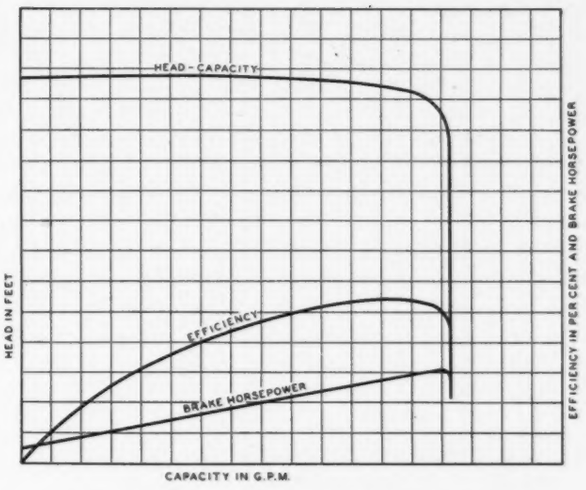


Fig. 4—Typical flat characteristic of centrifugal boiler feed pump.

horsepower curve which drops off abruptly directly at zero head and wide-open delivery—and the selection and use of a stock size of a driving unit corresponding to the horsepower requirements at the normal operating capacity and head conditions without resorting to the next larger size which is sometimes required for reduced head conditions with the straight line horsepower curve. A curve of this type, then, permits the use of a driving unit which will develop its maximum efficiency simultaneously with that of the pump and also prevents the pump from overloading the properly selected driving unit when the pump is operating under any condition of head and capacity. It will be noted that the maximum head of the head-gallon curve is at shut-off head and that the curve does not droop to the left as is the case with most head-gallon curves. This condition is due to the fact that the narrow width impellers accommodate the smaller capacities to better advantage, the impeller passageways being always full of water and the losses due to eddies being reduced to a minimum.

Fig. 6 shows a combined set of characteristics of a typical centrifugal boiler feed pump constructed from tests with the diffusion rings in place in a volute pump, and the same pump with the diffusion rings removed, the two sets of curves showing vividly the comparative characteristics between the diffuser and volute, or non-diffuser, type pump. In general, the head-gallon curve for the diffuser type pump droops in both directions from the maximum head: to the left slightly but abruptly to shut-off head and impending delivery and to the right steeply to zero head and a wide-open delivery. The head developed at impending delivery is therefore less than that at the maximum head for a capacity some distance to the right but the head at the impending delivery point is always greater than that at the point of normal operating, or maximum efficiency, conditions. The advantage of this slight droop to the impending delivery point is to insure a relatively low figure for the brake horsepower at the initial point on this curve. The

head-gallon curve for the volute type pump is more of the nature of a flat curve. It also droops slightly but gradually to shut-off head and gradually but rather steeply to zero head from the maximum point. The wide open delivery point is greater for the volute than the diffuser type pump due to the fact that the insertion of the diffusion rings constricts to some extent the water passageways in the pump casing. The shut-off head for the diffuser pump is considerably higher than that for volute pump. Likewise the heads for the capacities less than the capacity at the point where the two head-gallon curves intersect is greater for the diffuser than for the volute type. These conditions are due to the fact that the diffusion vanes convert the velocity head into pressure head thereby enabling the pump to deliver the same amount of water at greater heads with the same power consumption than the same pump would do with the diffusion rings removed.

The efficiency curve for the diffuser pump is more dome-shaped than that for the volute type, therefore the efficiencies of the former are considerably greater than those of the latter for all capacities less than that of the normal operating capacity, or the capacity for the maximum efficiency point, of the pump. The maximum efficiency point is closer to wide-open delivery for the volute than for the diffuser-type pump.

The brake-horsepower curves are practically identical with the exception that the curve for the volute type pump is slightly unloading, a condition, however, which is due to the construction of the impellers for the particular type of pump of which the test is a part. Unloading brake horsepower curves are possible with either the volute or diffuser type pump.

The curves shown in Fig. 6 illustrate vividly the advantages of the diffuser type pump. Starting with similar brake horsepower curves as shown, it is possible to deliver the same amount of water at increasingly greater heads toward shut-off with the diffuser than with the volute type pump with the same power consumption. Also

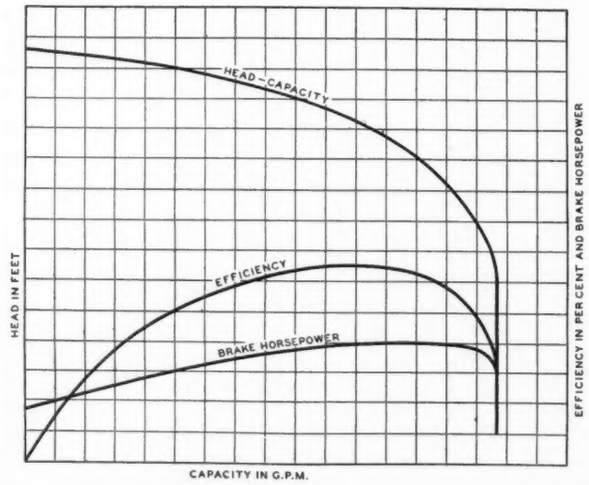


Fig. 5—Typical unloading brake horsepower curve for centrifugal boiler feed pump.

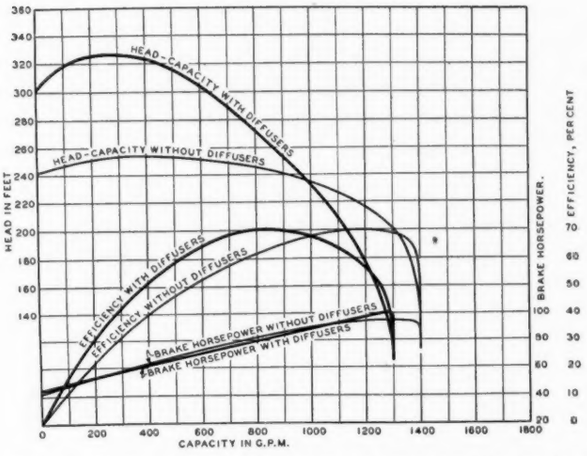


Fig. 6—Comparative characteristics of centrifugal boiler feed pump with and without diffusers.

the efficiencies for the lesser capacities are considerably greater for the diffuser pump. The maximum efficiency in any event is not necessarily greater for the diffuser than for the volute pump since it is possible to construct a volute pump with volute passages which will convert the velocity head into pressure head with no more loss than that by the diffusers in a strictly diffuser-type pump. However, it is easier to control the efficiencies at maximum, and other points by means of diffusers. It will be noted that the maximum efficiencies in this particular test are the same. For a standard stock casing, the efficiency of the diffuser pump, for the most part, is dependent upon the refinements of design and workmanship of the diffusion rings while the efficiency of the volute type pump is dependent upon the refinements and skill evidenced in the passageways in the pump. The greatest advantage of the diffuser pump is that the efficiencies at the lower capacities are considerably greater than those of the volute type pump. This advantage is of great importance in ordinary steam-plant practice since a boiler feed pump ordinarily operates under reduced capacity conditions the greater part of the time and the higher efficiencies of the diffuser type pump will result in a much lower operating cost.

Fig. 7 illustrates the effect of a variation in speed on the characteristics of a typical centrifugal boiler feed pump. For any pump operating with a variable speed driving unit:

1. The capacity varies directly as the speed,
2. The head varies as the square of the speed,
3. The brake horsepower varies as the cube of the speed.

These relations hold true only when the comparisons are made on the pump itself without change, that is, same casing, same rotating element, same diffusion rings, etc.

The head-gallon curves have the same general shape and slope. The shut-off points increase as the square of the speed and the wide open points directly as the speed. The efficiency curves also have the same general shape and slope. For the lower capacities, the efficiencies increase slightly as the speed increases due to the fact that the losses

due to friction which vary as the square of the velocity of the water are less than the losses due to eddying resulting from the passages in the impellers not being filled with water. The maximum efficiency increases slightly as the speed increases due to the fact that the pump was designed to operate at the highest speed noted. The brake-horsepower curves likewise have the same general slope and straight line variation with the exception of the one for the highest speed which is unloading. The unloading curve in this case is due to the fact that the width of the impellers is relatively narrow for the higher capacities at the speed noted, thereby inducing friction losses within the passages of the impellers which in turn results in a relatively abrupt drop in head.

The relations between capacity, head, brake horsepower and speed described in the previous paragraphs are used in constructing head-gallon curves for other speeds using as a basis a curve based on a test at a known speed. In Fig. 8, let the full line curve represent a head-gallon curve based on a test with a known speed of 1760 r.p.m. It is desired to construct a head-gallon curve for a speed of 2800 r.p.m. Selecting at random a point (1) on the 1760 r.p.m. curve where the head is 263 ft. and the capacity 100 g.p.m., then for a speed of 2800 r.p.m. the head will be $263 : x = 1760^2 : 2800^2$; whence $x = 665$ ft. and the capacity $100 : x = 1760 : 2800$; whence $x = 159$ g.p.m. For point (2) on the 1760 r.p.m. curve, where the head is 258 ft. and the capacity 150 g.p.m., the head will be $258 : x = 1760^2 : 2800^2$; whence $x = 654$ ft. and the capacity $150 : x = 1760 : 2800$; whence $x = 248$ g.p.m. on the 2800 g.p.m. curve. Sufficient other points are determined in the above manner until it is possible to construct as much of the broken line curve as is required.

This method of curve construction is convenient for determining the head-gallon curve for a steam-turbine-driven unit which is to operate at a speed other than the usual motor speeds such as 2800, 2400, 2000 r.p.m., etc. It is also used to determine the curves for 25 and 50 cycle current operation,

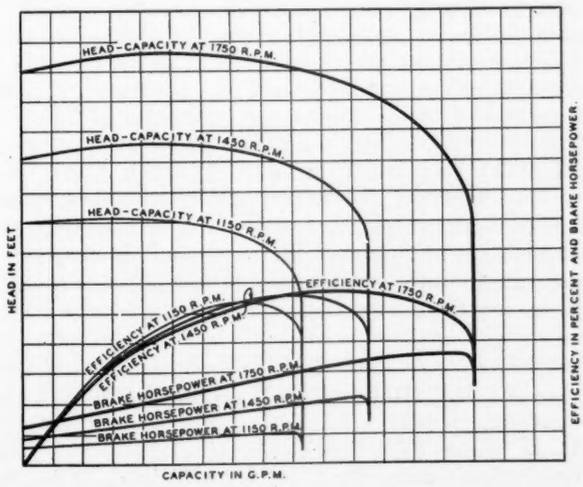

HEAD-CAPACITY AT 1750 R.P.M.
HEAD-CAPACITY AT 1450 R.P.M.
HEAD-CAPACITY AT 1150 R.P.M.
EFFICIENCY AT 1750 R.P.M.
EFFICIENCY AT 1150 R.P.M.
EFFICIENCY AT 1450 R.P.M.
BRAKE HORSEPOWER AT 1750 R.P.M.
BRAKE HORSEPOWER AT 1450 R.P.M.
BRAKE HORSEPOWER AT 1150 R.P.M.
HEAD IN FEET
EFFICIENCY IN PERCENT AND BRAKE HORSEPOWER
CAPACITY IN G.P.M.

Fig. 7—Illustrating effect of variation in speed on centrifugal boiler feed pump characteristics.

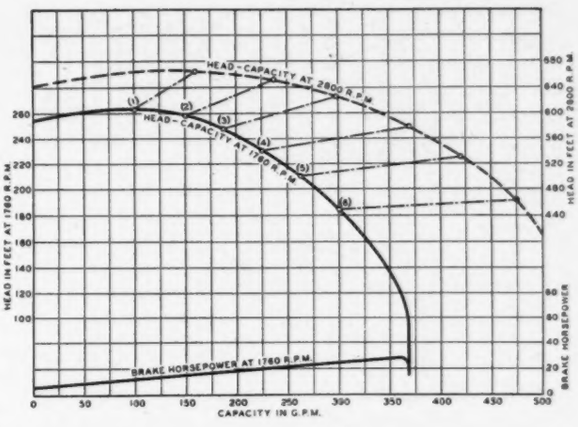

HEAD-CAPACITY AT 2800 R.P.M.
HEAD-CAPACITY AT 1760 R.P.M.
BRAKE HORSEPOWER AT 1760 R.P.M.
HEAD IN FEET AT 1760 R.P.M.
HEAD IN FEET AT 2800 R.P.M.
BRAKE HORSEPOWER
CAPACITY IN G.P.M.

Fig. 8—Illustrating a head-gallon curve for another speed constructed from a curve based on tests from a known speed.

such as 1450, 1900, 2900 r.p.m., etc., since most testing laboratories have only 60 cycle current available for the usual 60 cycle speeds of 1150, 1750, 3450 r.p.m., etc.

Fig. 9 shows the speed variation in a typical centrifugal boiler feed pump installation necessary to maintain a constant head with variable delivery. The normal operating point is at 300 g.p.m. delivery and 616 ft. head which is obtained on test at 1760 r.p.m. For a delivery of 250 g.p.m., for example, the head will rise to 651 ft. if the speed is maintained at 1760 r.p.m. If, however, it is desired to maintain the same head, 616 ft., then it is necessary to reduce the speed. For 250 g.p.m. and 616 ft. head, the speed will be $616 : 651 = x^2 : 1760^2$, whence $x = 1712$ r.p.m. for 200 g.p.m. and 616 ft. head, the speed will be $616 : 677 = x^2 : 1760^2$, whence $x = 1679$ r.p.m. and so on.

A variable discharge in a centrifugal boiler feed pump installation can be effected in two ways, viz:

1. By throttling the discharge,
2. By varying the speed of the driving unit.

Varying the capacity of the pump by throttling the discharge has the advantage of the driving unit operating at its maximum efficiency at the particular point of operation but also has the disadvantage of an increasing head on the head-gallon curve as the capacity is decreased. The latter results in a relatively high brake horsepower and a consequent relatively high power requirement. For example: In Fig. 9, the brake horsepower for 300 g.p.m. is equal to $\frac{300 \times 616}{3960 \times .67} = 69.5$, for 200 g.p.m., the brake horsepower will be $\frac{200 \times 676}{3960 \times .60} = 56.8$, and for 100 g.p.m., the brake horsepower will be $\frac{100 \times 704}{3960 \times .39} = 45.6$. If a 75 hp. electric motor is used as the driving unit, it

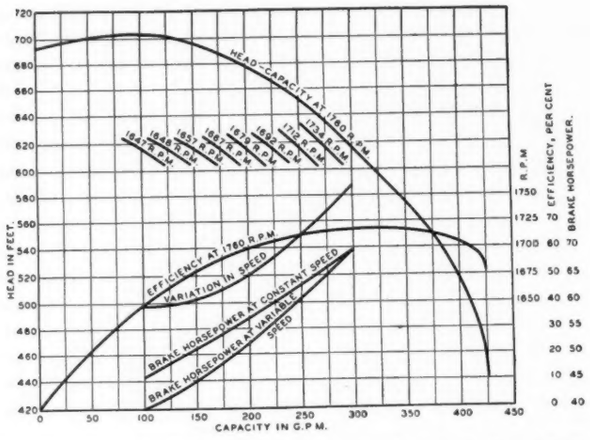


Fig. 9—Curves showing variation in speed at centrifugal boiler feed pump for constant head and variable discharge.

will operate at an efficiency of approximately 90 per cent at 300 g.p.m. and 69.5 brake hp. with a drop of less than 2 per cent when operating at 100 g.p.m. and 45.5 brake hp. If a 75 hp. steam turbine is used as the driving unit, it will operate with a water rate of approximately 40 lb. per brake hp. per hr., depending upon the steam pressure, degree of superheat and amount of back pressure, at the higher capacity with an increase of less than 5 per cent when operating at the lower capacity.

Varying the capacity of the pump by varying the speed of the driving unit has the advantage of a constant head on the head-gallon curve with a consequent relatively low brake horsepower but has the disadvantage of energy losses in the driving units due to the variable speed mechanism. A varying speed with a constant head results in a relatively low brake horsepower with a consequent relatively low power requirement. For example: In Fig. 9, the brake horsepower for 300 g.p.m. is equal to

$$\frac{300 \times 616}{3960 \times .67} = 69.5$$

: for 200 g.p.m., the brake horsepower will be

$$\frac{200 \times 616}{3960 \times .60} = 51.8$$

: and for 100 g.p.m., the brake horsepower will be

$$\frac{100 \times 616}{3960 \times .39} = 40.$$

In the case of a variable speed motor, a considerable amount of energy is lost through the resistance in effecting the decrease in speed although by proper application this loss can be reduced to a minimum. When a steam turbine is used as the driving unit, in addition to the primary fractional load correction, which is the ratio of the actual brake horsepower of the pump to the maximum horsepower for which the turbine was designed, which must be applied to the water rate, a secondary fractional load correction, which is the ratio of the horsepower which the turbine develops at the reduced speed to the horsepower which it develops at the speed for which it was designed, must also be applied.

The variation in the brake horsepower involved at constant speed and also at variable speed is shown by Fig. 9. In making these comparisons, it was assumed that the efficiency of the pump at both constant and variable speed remains constant for the various capacities and corresponding heads. As the speed decreases, the efficiency increases slightly at the lower capacities and the brake horsepower involved will be somewhat less.

The results of the analyses of the various curves made heretofore show the importance of a complete set of operating characteristics for every centrifugal boiler feed pump installation. Not only is it possible to determine the operating point of the pump at any moment from these curves but also the cost of pumping can be calculated from the data obtainable from them. Sensitive gages at both the suction and discharge ends of the pump will give the necessary pressures from which the head against which the pump is operating can be obtained. The head, in turn, locates the capacity on the head-gallon curves and also the efficiency of the pump at the particular operating point, together with the barke horsepower involved.

U. S. Government Exercises Contract Option for Additional Boiler Units For New Triangle Heating Plant

The contract awarded to Combustion Engineering Corporation in March of this year by the United States Treasury Department, Washington, D. C., covering 4 complete steam generating units for the new Triangle Heating Plant, contained an option to purchase two additional duplicate units. The government has now exercised this option, and Combustion Engineering Corporation has received the contract for the two additional units.

These units, like the four on the original contract, are designed for 400 lb. pressure and are guaranteed for a continuous production of 215,000 lb. of steam per hr. and a maximum production of 237,000 lb. per hr. from and at 212 deg. fahr.

The contract includes boilers, stokers, steel-encased boiler settings, water-cooled furnaces, and forced and induced draft fans and drives.

United Engineers & Constructors, Inc., Philadelphia, are the consulting engineers.

The A.S.M.E. Boiler Code Committee, at the May meeting, elected the following new members: R. E. Cecil, Vice President, Air-Tight Steel Tank Co., Pittsburgh, Pa.; A. C. Weigel, Manager, Boiler Division, Combustion Engineering Corporation, New York.

Treatment of Feedwater for High Pressure Boilers

By C. E. JOOS
Chemical Engineer
Cochrane Corporation, Philadelphia, Pa.

Much has been written during the past few years on the subject of boiler feedwater treatment. While progress has been rapid, new problems have been constantly introduced and there is still much to be found out about this highly important aspect of steam plant operation. The publication of the opinions and experiences of those engaged in this field, will in the course of time, serve to establish reliable principles of practice applying to all of the many variables of the problem. The author presents a current review of practice and methods particularly as they apply to high pressure boilers.

HIGH steam pressures have focused attention on problems relating to boiler feedwater. Water supplies which were considered excellent for low pressure boilers are found to have undesirable characteristics in high pressure boilers, therefore, high pressure plants now are being equipped with water softening or conditioning systems, expenditure for which in the past may not have been considered as justifiable. A reason for this change in attitude is to be found in the fact that the high pressure boiler of today has elaborate water walls and is operated at ratings formerly quite exceptional.

In addition to the high rates of heat transfer for which practically all high pressure boilers are now designed, the correspondingly high temperatures cause physical changes in the nature of the incrusting solids. Both calcium sulphate and calcium carbonate become more insoluble at the higher temperatures, which accelerates the deposition of scale. Also, the tendency to formation of calcium silicate scale is more pronounced at higher pressures and while such scale may not grow to an appreciable thickness, it is usually of such a character that very thin coating may result in burning and rupture of tubes.

The severe duty which must be performed by the high pressure boiler renders chemical treatment of the feedwater imperative in order that evaporating surfaces may be kept clean and protected against corrosion. There are also additional requirements which must be met in the selection, control and design of a system of feedwater treatment. By meeting such requirements a balanced treatment is achieved, but it must not be inferred that any one type of feedwater treatment can be made the standard, as local limitations as to space, heat balance, first cost, etc., may favor the selection of one feedwater system over another which is possibly better suited to the chemical characteristics of the raw water.

Requirements of Balanced Treatment

To determine upon a balanced feedwater treatment the following factors should be considered.

1—Freedom from deposits on boiler evaporating surfaces and in feed lines and economizers.
2—Low concentration of solids and alkali in the boiler water.
3—Protection against embrittlement of boiler metal.
4—Protection against corrosion of piping, economizer and boiler.
5—Low operating costs and minimum of service and attention.

Prevention of Deposits

It has been demonstrated conclusively that absolute freedom from scale can be maintained by modern feedwater conditioning equipment. Plants are in operation in which 100 per cent of the boiler feed is treated make-up, with steam pressures of 400, 600, and 700 lb. per sq. in., where complete protection of water-cooled walls, tubes, etc. is obtained, which is significant as the waterwalls are rarely, if ever, blown down. The success of chemical conditioning in such severe service has been such that some central stations, using only a small percentage of make-up, are now turning to softening instead of evaporation of make-up.

An excess of soda ash in the boiler, whether this soda ash is the result of internal treatment, lime-soda or zeolite softening, is no longer universally depended upon for the maintenance of clean evaporating surfaces and as meeting the exacting de-

mands of high pressure boilers where a high percentage of availability is desired. While some cases indicating satisfactory conditions have been reported[1], the fact remains that a soda-ash treatment is handicapped in two definite respects:

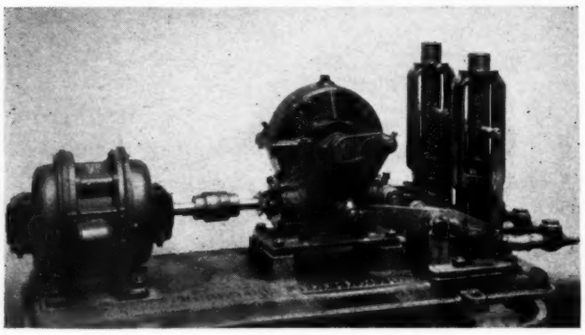


Fig. 1—High pressure plunger pump for feeding phosphate directly to high pressure boilers.

(a) Lack of stability of the carbonate radical, upon which dependence is placed for prevention of scale,
(b) Failure to prevent silicious scales.

As is well known, under the influence of high temperatures there occurs a high percentage of conversion of soda ash to caustic, and at 400 lb. pressure and above the decomposition may exceed 85 per cent.[2]

The high alkalinity necessary to provide a safe margin of carbonate radical available, as well as to keep the calcium carbonate sludge non-adhering may bring about a condition detrimental from the standpoint of foaming, priming and establishment of a satisfactory embrittlement ratio.

The formation of silicate scale cannot be entirely eliminated by soda ash or caustic boiler alkalinity, and, while increasing these concentrations brings about material improvement, the mere maintenance of a high boiler alkalinity cannot be regarded as a complete preventive of the formation of this type of scale.

To satisfy the conditions of the high pressure boiler a chemical treatment must have the following characteristics:

(a) Prevention of scale of all types, as sulphate, carbonate and silicate.
(b) Stability under boiler conditions, so that only a small excess will be required in the boiler.

Phosphate Treatment

The use of sodium phosphate in its various forms fits the requirements of high pressure boilers nicely, and it is now common practice to use phosphate chemicals for internal conditioning, either alone or supplementary to other softening processes. The phosphate radical is stable and calcium phosphate sludge is fine, non-adherent and easily removed with the blowdown. Also phosphate solves a most difficult problem, namely, the prevention of calcium silicate scale. The writer has known cases where the formation of silicate scale could not be prevented by soda ash treatment, even with high boiler alkalinities, yet the deposits were entirely prevented by phosphate treatment.

While phosphate is ideally suited to the treatment of feedwater for high pressure boilers, it cannot be used indiscriminately. Calcium phosphate is less soluble than either calcium sulphate or calcium carbonate, so that when added to feedwater containing these salts, precipitation occurs at once; also when calcium carbonate is precipitated by phosphate, sodium carbonate is formed as a by-product, similar to that which occurs in softening by zeolite.

Phosphate deposits in the feed lines or boiler feed pump can be overcome by introducing the phosphate by shots or intermittently so that the time of contact of the phosphate is greatly reduced and therefore the possibilities of deposits diminished.[3] In many plants the phosphate is fed directly to the boilers, circumventing any possibilities of trouble. Circumstances dictate which method is most desirable and equipments are now on the market which automatically feed the phosphate intermittently, as also equipments for direct feeding.

A high pressure, heavy duty pump for feeding phosphate directly to the boiler is shown in Fig. 1, while Fig. 2 illustrates a method using the displacement principle, in which the difference in pressure between the boiler feed pump and boiler proper is utilized as a means of forcing the phosphate to the boiler. Some oil, such as light colored kerosene, separates the boiler feedwater and the phosphate solution. This method has proved quite successful in operation and has the advantages of low operating cost and simplicity.

Since in its reaction with calcium carbonate, phosphate produces sodium carbonate as a by-product, as follows:—

$$3CaCO_3 + 2Na_3PO_4 \rightarrow Ca3(PO_4)_2 + 3Na_2CO_3$$

the residual calcium carbonate hardness is a potential source of sodium carbonate, which tends to increase the boiler alkalinity above that resulting without phosphate. It is therefore evident that the greater the carbonate hardness the greater the resultant sodium carbonate, which, if produced to a greater extent than that necessary to prevent scale and corrosion, is detrimental to the production of dry steam generation and maintenance of the recommended embrittlement ratio. With waters already high in carbonate, balancing of the feedwater treatment obviously necessitates that this potential source of sodium carbonate be reduced either by a pre- or after-treatment of sulphuric acid or by precipitation of the carbonates by means of lime. Treatment with lime is preferable, because it removes the carbonates from solution, decreasing the solids, whereas acid simply

[1] Solubility of Calcium Salts in Boiler Water.—F. G. Straub's paper presented A.S.M.E. Meeting, Nov. 30 to Dec. 4, 1931.

[2] Decomposition of Sodium Carbonate in Steam Boilers, by Reinhold F. Larson, A.S.M.E. Meeting, June 1 to 3, 1931, Hartford, Conn.
Conversion of Soda Ash to Caustic Soda Within Steam Boilers, by C. E. Joos, Power, Nov. 12, 1929

[3] Phosphate Deposits Eliminated by Quick Feed, by A. B. Stickney, Power, June 16, 1931, p. 947.

converts the carbonates to sulphates, thereby increasing the solids in the boiler.

Low Concentration of Solids and Alkali

It is desirable in order to avoid foaming and priming that a system should give low concentration of alkali, especially in modern boilers driven at high ratings and having only small steam liberating surface. Steam purifiers and continuous blow-down systems have done much to combat or prevent foaming, but obviously, correct water treatment should be looked to as the first means of preventing contamination of the steam. Control of the feedwater treatment is a means of maintaining low concentration of alkali in the boilers for by feeding the boiler with water low in carbonate, the alkalinity in the boiler may be converted largely to tri-sodium phosphate, which apparently does not have the foam producing qualities of an equivalent amount of sodium hydrate or sodium carbonate alkalinity.

Table I shows how the foaming tendencies of a boiler water softened by zeolite without phosphate treatment can be controlled, with reduction in boiler alkalinity, by the addition of sulphuric acid. The total alkalinity was determined by methyl orange indicator and the foaming qualities by violent agitation in a stoppered bottle, observing the duration of the foam so produced. The data illustrate the relation of hydrate and carbonate alkalinity to foaming qualities.

TABLE I

Grains per Gallon Alkalinity	Duration of Foam in Seconds
14.6	55
11.6	30
8.6	15
5.6	12
2.6	8
0.0	5

Table II shows the effect of adding varying quantities of mono-sodium phosphate to a foaming boiler water. There is a marked decrease in foaming tendency, as the alkalinity is converted to the tri-sodium phosphate form without any change in the total alkali as indicated by the methyl orange indicator.

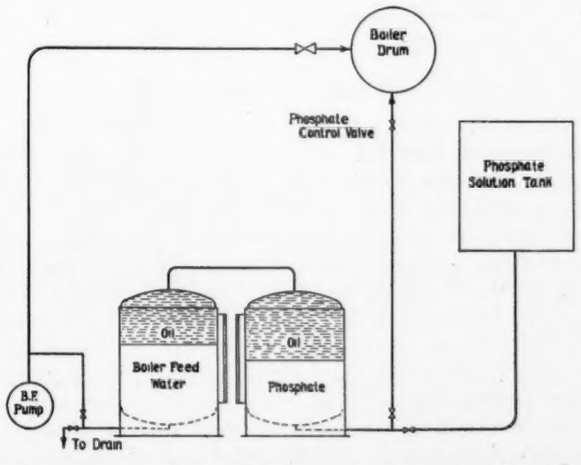


Fig. 2—Displacement method of feeding phosphate directly to high pressure boilers.

TABLE II

Grains per Gallon NaH_2PO_4	Grains per Gallon Pht. Alkalinity	Grains per Gallon M. O. Alkalinity	Duration of Foam in Seconds
—0	14.4	17.5	298
2	14.0	17.4	219
4	12.9	17.4	195
6	12.5	17.5	85
8	11.9	17.5	79
10	9.0	17.4	45

One plant using phosphate in one boiler has reported better steaming conditions in that boiler than in adjacent boilers not receiving the same phosphate treatment but using water from the same softener. It is evident from the above that caustic alkalinity is more effective in causing foaming than is concentration of solids, for in both cases the addition of sulphuric acid and of mono-sodium phosphate increased the total solids. It is fortunate that in the mono-sodium phosphate we have an acid property which reduces the causticity of the boiler water in the formation of tri-sodium phosphate. A greater reduction in causticity might be effected by the use of phosphoric acid, but this reagent has been used only occasionally, as the mono-sodium salt brings about sufficient reduction in all but rare instances.

The above indicates the relation of causticity and solids to foaming, but it is also a fact that while solids may not be of first importance they nevertheless cannot be ignored, otherwise it would not be necessary to blow down. The effect of high concentration of salts, other than causticity, is well known and it is obvious that a system of boiler feedwater treatment should provide for reduction of solids wherever possible, and also be flexible enough to provide for obtaining a low caustic content in the boiler concentrate.

Embrittlement

Embrittlement of boiler plate has received much attention in the past five years, particularly in plants operating at high pressures. The A.S.M.E. Boiler Code recommends that the ratio of sodium sulphate to sodium carbonate be maintained at 3 to 1, and most plants are following this rule, by the maintenance of low alkali or by the introduction of sulphate or by a combination of these methods. Maintenance of the sulphate ratio is by far the most conservative course to follow, although in some of the plants carrying very high pressures, where the maintenance of this ratio would imply the introduction of excessive quantities of sulphate, dependence is placed on the presence of the phosphate radical. While some very good laboratory results indicate that this is satisfactory, the sulphate ratio has stood the test of time and is generally considered the safest rule to follow.

The ratio recommended may be attained by any

one of a number of methods, such as the maintenance of low concentrations of alkali, feeding of sodium sulphate or sulphuric acid or preliminary treatment by lime in the case of a zeolite softening system. By far the best procedure is to maintain

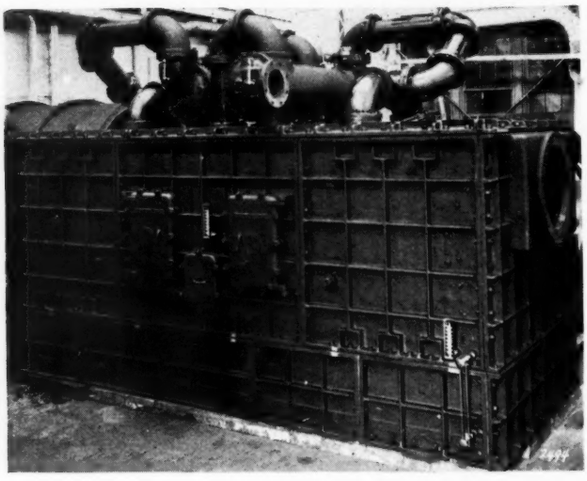


Fig. 3—Deaerating feedwater heater—capacity 1,000,000 lb. per hr.

low alkalinity in the boiler concentrate, for with each reduction of one part of alkali the sulphate requirement is reduced by three parts and the total solids by four parts. The phosphate treatment makes this possible, through the fact that the low alkalinities which protect against embrittlement are also satisfactory from the standpoint of scale and corrosion. Thus in some high pressure plants boiler water alkalinities as low as five to ten grains per gallon have proved very satisfactory. These low boiler alkalinities make it possible to maintain the three to one ratio without the introduction of sulphate, with all but exceptional water supplies.

The fact that forged or welded drums are being used more frequently in the construction of modern high pressure boilers does not lessen the necessity of preventing embrittlement, for embrittlement may occur at the joints where the tubes are expanded into the drums.

Corrosion

Boilers operated at high pressures, with the attendant high temperatures, demand greater care to avoid corrosion, as the tendency of feedwater to corrode is governed by its temperature, pH value and oxygen content. It is now generally conceded that all feedwater should be deaerated. The content of dissolved oxygen should be reduced not only to 0.025 to 0.06 cc. per liter, which is the common understanding, but absolute zero by the Winkler test is deemed to be desirable. There are equipments now on the market for which this performance is guaranteed, and Fig. 3 illustrates a modern deaerating heater designed for a central station and having a capacity to deaerate 1,000,000 lb. per hr.

There have been, however, cases where corrosion occurred, even though the oxygen content had been maintained continuously close to zero. In such cases the corrosion was greatly accelerated by the relatively low pH value. The pH value of the treated make-up water supply should be maintained above 9.0. Fig. 4 shows the corrosion which occurred in 10 days on a test piece of cold rolled steel placed in a feed line carrying water having the characteristics illustrated by Table III.

TABLE III

Tests	pH	O_2 cc. per Liter
1	8.8	0.00
2	8.8	0.00
3	8.9	0.00
4	8.9	0.00
5	8.8	0.03
6	8.6	0.03
7	8.8	0.05
8	8.6	0.03
9	8.6	0.03

The oxygen content can be controlled either by deaerating equipments or by the introduction of chemical reducing agents, such as ferrous hydrate, as accomplished at the Lakeside Station.[4] The control of the pH value is governed by the chemical treatment or by recirculation of boiler water, which method was used to correct the corrosion shown in Fig. 4. Chemical treatment has the advantage over recirculation that it does not increase pumping charges nor degrade heat from the boiler to the feedwater heater, replacing heat which might be obtained to better advantage from exhaust or bled steam. Recirculation is also handicapped where phosphate treatment is used, because with the introduction of soluble phosphate continuously with the feedwater, feed line deposits are sure to occur, resulting in disturbances in feedwater flow and regulation, as well as necessitating periodical removal of deposits or installation of new and duplicate feed lines.

Method of Treatment

To accomplish a balanced treatment, a number of systems of feedwater treatment have been advanced, as follows:

(a) Treatment internally of the boiler.
(b) Hot process lime and soda softeners.
(c) Zeolite softeners.
(d) Evaporators.

Internal Treatment

Internal treatment of water in high pressure boilers is successful only with very soft water supplies, such as might be found in the City of New York and in certain parts of New Jersey and New England, as well as in other districts using clear mountain water. With such water supplies, where the total hardness does not exceed approximately two grains per gallon, and where corrosive tendencies are completely corrected by deaeration, primary softening equipment may not be required. The percentage of make-up has little bearing on whether or not internal treatment is desirable, for with only a small percentage of highly carbonated

[4] N.E.L.A. Publication No. 051, June, 1930, "Treatment of Feedwater," page 20.

make-up the ultimate concentration in the boiler will be comparable to that found where there is a larger percentage of make-up wih corresponding blow-down schedule. The character of the water is the primary consideration. Treatment of water of high hardness in the boiler requires an extravagant use of phosphate, whereas softening the water preliminary to its introduction into the boiler would reduce this hardness by the use of cheaper chemicals, such as lime and soda or salt. Where the carbonate hardness is high, internal treatment will release greater amounts of carbon dioxide than would be released from water which had received preliminary treatment in a water softener. The carbon dioxide tends to accelerate corrosion, particularly in condensate return lines, where it gives rise to a low pH value.

With very soft waters, where softeners do not show appreciable value in reduction of hardness or in saving phosphate, or in the balancing of a feedwater treatment, we enter the field of internal treatment, which numerous plants employ successfully, using phosphate or a combination of phosphate and some alkali, such as caustic soda.

It is good practice with internal treatment to feed an acid type of phosphate, such as monosodium phosphate or the meta variety intermittently into the suction of the boiler feed pump or directly to the boilers, continuously or intermittently, and to feed an alkali, such as caustic soda, continuously into the feedwater for the production of the necessary boiler alkalinity and to raise the pH value of the feedwater for the prevention of corrosion in feed lines and economizers. The feeding of these chemicals separately becomes desirable with certain waters of very low carbonate content but high in free CO_2, which gives a low pH value and, therefore, corrosive tendencies. In other cases, the pH value of the raw water may be such that after deaeration it is not corrosive and the addition of alkali and phosphate may be made in the form of one chemical, such as di- or trisodium phosphate.

Fig. 4—Corrosion illustrated by piece of cold rolled steel placed in feed line and subjected to water conditions illustrated in Table III.

A typical example of internal treatment of very soft water is afforded by the Kips Bay Station of the New York Steam Corporation. Here the chemicals are fed directly to the boilers, the supply to each boiler being regulated manually, using an orifice and manometer as an indication of the quantity of phosphate flowing. This installation has been very successful.[5]

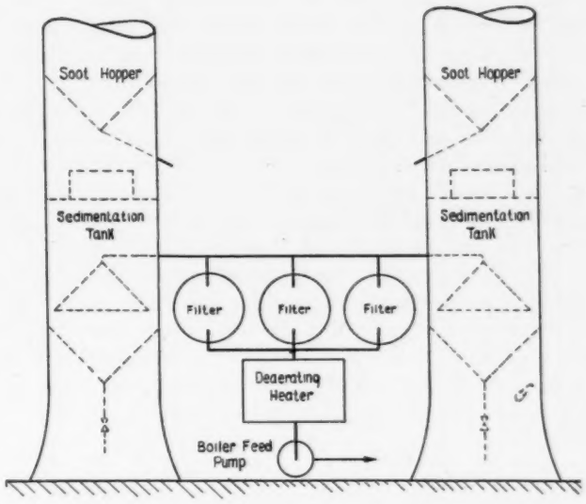


Fig. 5—Hot process water softener at Grand Avenue Station of Kansas City Power and Light Company, Kansas City, Missouri.

Hot Process Lime and Soda Softener

Where feedwater contains appreciable hardness, a primary softening system is essential to the economical production of a balanced treatment. With carbonated or turbid waters, the hot process lime and soda method of softening lends itself admirably to the reduction of hardness and to balancing of the treatment preparatory to the supplementary treatment by phosphate. The advantages of the hot process lime and soda softener for the preparation of feedwater are due to the fact that it removes hardness by precipitation, the carbonate being brought down to a low limit and the entire operation being under the control of the operators insofar as the general character of the water leaving the softener is concerned. Thus, with such a system the operator has a certain amount of control over the residual hardness and the amount of excess alkali to be carried, together with the character of this alkali, that is, whether it is to be bi-carbonate or caustic, thereby giving a means of controlling the pH value.

Another advantage of the hot process treatment lies in the fact that with turbid waters no preparatory treatment is necessary, since clarification is performed simultaneously with the softening process. A water thus softened and completely deareated will not corrode the most sensitive equipment, such as steel tube economizers. It is the

[5] "Development of High Pressure Boiler Water Conditioning," by A. A. Markson, Combustion, April, 1930.

simplicity of such a system, with the definite control that it affords over the quality of feedwater, that has led many industrial plants requiring large quantities of make-up to use the hot process, and a definite trend exists today toward the use of this type of softening equipment.

In central stations, or in heating plants where the character of the condensed steam affects the corrosion of condensate lines, the lime treatment offers the advantage of precipitating the bicarbonates and free carbon dioxide from solution, so that the amount of carbonate radical entering the boilers is reduced to the very minimum, namely, the small quantity of carbon dioxide which results from the decomposition of sodium carbonate. As an example, at the Grand Avenue plant of the Kansas City Power and Light Company, a 58,000 gal. per hr. hot process lime and soda softener prepares feedwater for 600 lb. pressure boilers. In winter, the plant supplies a heating system from which no condensate is returned and the make-up, therefore, approaches 100 per cent of the total boiler feed. In summer, the plant operates condensing, with only a small quantity of make-up. The results have been very gratifying, and in three and one half years of operation it has not been necessary to turbine the boilers once. The water supply is highly carbonate, as might be expected in this district, but a balanced treatment is effected, resulting in satisfactory operating conditions. A somewhat unusual feature was the use of the lower portions of the steel stacks as sedimentation tanks, as illustrated diagramatically in Fig. 5.

Zeolite Water Softeners

Carbonate hardness predominates in most hard water supplies, which fact renders the zeolite softener unsuitable for the production of a properly balanced treatment, although this handicap can be corrected either by a pre-treatment with lime or by an after-treatment with sulphuric acid. The handicap is due to the fact that zeolite softening is not a precipitation process, but rather one of exchange of sodium for calcium and magnesium. Thus, if a raw water contains, for example, 10

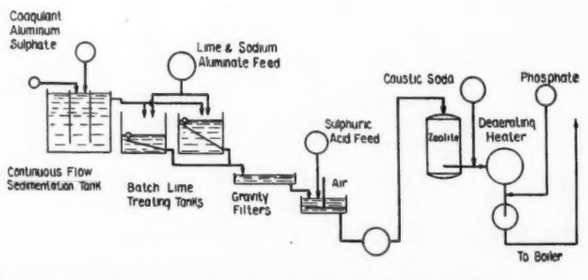


Fig. 6—Diagrammatic sketch of feedwater cycle Beacon Street Heating plant of Detroit Edison Company.

grains per gal. of calcium carbonate, there will be produced 10.6 grains per gal. of sodium carbonate. Turbid waters require pre-sedimentation and filtration before passage through the zeolite filter. A lime treatment can be incorporated with the sedimentation process to reduce the carbonate content simultaneously with the removal of suspended matter. After the lime treatment, there is a possibility of carbonate deposits and the water must be stabilized by the introduction of either carbon dioxide, coagulant or acid. It is, of course, advan-

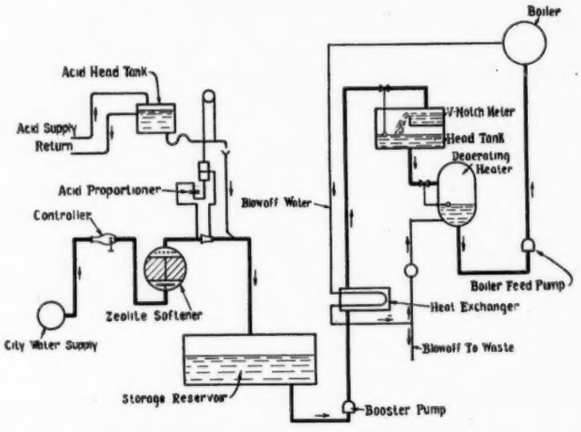


Fig. 7—Diagrammatic arrangement of feedwater cycle of Louisiana Steam Products Company.

tageous from the standpoint of maintaining the pH value, to use just as little stabilizing agent as possible. Re-treatment with zeolite softening and deaeration may result in a balanced feedwater. However, the pH value is not likely to be as high as that obtained with the hot process lime and soda softener and, therefore, the tendency to corrosion will be greater.

Where clear water is used, as obtained from wells or city water supplies, it is customary to follow the zeolite softening by treatment with sulphuric acid. The acid treatment performs the double function of diminishing the alkali and increasing the sodium sulphate, which may be required where the sulphate content of the raw water is not sufficiently high to establish a 3 to 1 ratio. This further introduction of sulphate by acid treatment adds to the total solids. The introduction of acid should be followed by standing in a tank or storage reservoir for the liberation of the free carbon dioxide. Ordinarily the water is then deaerated and delivered to the boilers. Since all of the alkali in the zeolite softened water is of the bicarbonate type, which will necessarily have a comparatively low pH value, corrosion is likely to occur, even in spite of practically complete deaeration. This fact is illustrated by experience at the Beacon Street plant of the Detroit Edison Company, where the lack of balance in the feedwater treatment was corrected by recirculation of the concentrated boiler water through the deaerating heater, as illustrated in Fig. 6, the pH value being thereby increased to 9.8 and corrosion prevented.

In using phosphate treatment in connection with high pressure boilers, recirculation is a distinct disadvantage, since the recirculation must be continuous, and, as the boiler water will contain soluble phosphate, there are sure to be feed line deposits. It is, therefore, better to establish a balance

by pre-treatment with lime rather than by after-treatment with acid. One plant employing such a system successfully is that of the Louisiana Steam Products Company, whose general scheme of feedwater treatment is illustrated in Fig. 7, the steps shown all being necessary to bring about a balanced feedwater treatment and to satisfy all requirements. A typical example of zeolite softening and after-treatment with acid is found at the Detroit Edison Company's Beacon street plant, the general scheme of which is outlined in Fig. 6. This is a low pressure plant using the same form of treatment that has been applied in high pressure installations, particularly central stations. The Calumet Station of the Commonwealth Edison Company uses zeolite softening with after-treatment by acid.

Evaporators

Evaporators have found wide application in the preparation of small quantities of make-up in central stations, and have also gained some headway in industrial plants in connection with high pressure boilers. For large quantities of make-up the transformer type of evaporator is employed, in which the evaporator receives steam at boiler pressures and generates process steam at a lower pressure. Thus no raw make-up is fed to the boiler, the make-up being supplied through the evaporators; in other words, the feedwater problem is transferred from the boiler to the evaporator. Under ideal conditions, where the carbonate hardness in the water is not high, simple evaporation without accessory chemical treatment has proved satisfactory. However, in most cases, even where only a small amount of make-up is required, as in central stations, chemical treatment in the boiler is necessary in order to prevent formation of scale, due to priming of the evaporator, leakage of condensers, etc. Even if the evaporator were perfect in operation, that is, were not subject to foaming and priming, and assuming that the scale could be cracked from the tubes readily and that there would be no condenser leakage, the feedwater would still be in an unbalanced condition from the standpoint of corrosion, for the pH value would be low, and it would be necessary to add alkali in the form of caustic soda or phosphate to prevent the corrosion of boiler metal. Frequently, evaporators are installed for use with high carbonate waters, and the scale formed is not brittle so that pretreatment is found necessary. Today there is a tendency to depart from the use of evaporators for the preparation of make-up, due to the degradation of heat that is unavoidable in their operation. Several central stations operating at high pressures are now using make-up softened by the hot process and there are also installations of zeolite softeners. The trend to water softeners has probably been brought about by the fact that experience gained during the last several years in the preparation of feedwater for high pressure boilers has demonstrated conclusively that softeners afford a balanced treatment, resulting in full and complete protection to boiler units.

Boiler, Stoker and Pulverized Fuel Equipment Sales

As reported by equipment manufacturers to the Department of Commerce, Bureau of the Census.

Boiler Sales

Orders for 264 boilers were placed in May by 72 manufacturers

	Number	Square feet
May, 1932	264	254,549
May, 1931	604	499,571
January to May (inclusive, 1932)	1,231	1,312,419
Equivalent period, 1931	2,815	2,708,032
Total, 1931	7,508	6,327,262

NEW ORDERS, BY KIND, PLACED IN MAY, 1931-1932

Kind	May, 1931 Number	May, 1931 Square feet	May, 1932 Number	May, 1932 Square feet
Stationary:				
Water tube	48	208,628	33	116,381
Horizontal return tubular	44	55,675	18	16,238
Vertical fire tube	44	15,865	47	25,266
Locomotive, not railway	9	4,312	5	4,826
Steel heating	422	189,195	145	77,863
Oil country	4	4,528	....	.....
Self contained portable	26	18,259	14	12,280
Miscellaneous	7	3,109	2	1,695
Total	604	499,571	264	254,549

Mechanical Stoker Sales

Orders for 71 stokers totaling 14,049 hp. were placed in May by 55 manufacturers

	Installed under: Fire-tube boilers No.	Fire-tube boilers Horsepower	Water-tube boilers No.	Water-tube boilers Horsepower
May, 1932	41	5,240	30	8,809
May, 1931	113	14,779	54	19,891
January to May (inclusive, 1932)	314	42,212	139	62,831
Equivalent period, 1931	480	62,939	219	78,157
Total, 1931	1,889	252,571	574	187,507

Pulverized Fuel Equipment Sales

Orders for 7 pulverizers with a total capacity of 39,250 lbs. per hr. were placed in May

	STORAGE SYSTEM: Pulverizers: Total Number	No. for new boilers, furnaces and kilns	No. for existing boilers	Total capacity lb. coal per hour for contract	Water-tube Boilers: Number	Total sq. ft. steam generating surface	Total lb. steam per hour equivalent
May, 1932	..	..	..	.....	..	.....	.....
May, 1931	..	..	..	.....	..	.....	.....
January to May (inclusive, 1932)	..	..	..	.....	..	.....	.....
Equivalent period, 1931	7	6	1	220,000	3	114,577	1,671,000
Total, 1931	8	7	1	250,000	4	126,471	1,797,000
DIRECT FIRED OR UNIT SYSTEM							
May, 1932	3	3	..	36,000	2	22,947	290,000
May, 1931	..	..	..	.....	..	.....	.....
January to May (inclusive, 1932)	28	22	6	162,488	23	151,106	1,512,450
Equivalent period, 1931	32	27	5	219,750	24	190,080	2,429,875
Total, 1931	72	52	20	450,960	58	417,327	4,455,585
					Fire-tube Boilers		
May, 1932	4	..	4	3,250	4	5,500	30,500
May, 1931	3	1	2	3,800	3	6,000	27,000
January to May (inclusive, 1932)	8	..	8	8,050	8	13,500	71,500
Equivalent period, 1931	15	2	13	18,800	15	26,204	170,200
Total, 1931	35	11	24	39,300	37	59,761	347,100

Heat Loss through Firebrick

By R. C. DENNY, New York

This is a very simple and concise presentation of the subject, the practical value of which is enhanced by the inclusion of two charts, one showing a new thermal conductivity curve for high-grade standard firebrick and the other showing heat transmission curves for firebrick walls of various thicknesses. The mathematics for determining heat loss through refractory walls is clearly outlined and an example worked out. This discussion will be concluded in a subsequent article.

INDUSTRIAL competition is directing increased attention to insulation of hot surfaces against the loss of heat by radiation. Boiler furnaces, as well as boiler walls, are receiving insulation treatment. So also are the lower temperature furnaces used in oil stills and metallurgical heat treatment.

The many questions raised as to heat losses through various combinations of furnace lining and insulating materials, must be fairly met by some uniform method of calculation. The purchaser is usually loath to accept figures and curves of heat losses presented by the manufacturers of materials. He prefers to make his own impartial check on heat losses. In view of the calculating material available there is no reason why he should not do so.

Heat transfer through the materials customarily used in furnace walls and roofs is proportional to the difference in temperatures of the hot and cold faces of such materials. The heat transferred is expressed by the formula:

Equation (1) $$H = \frac{C(T - t)}{S}$$

where H is the heat transferred, T and t are the hot and cold face temperatures, S is the thickness of the material, and C is the conductivity factor for the material.

This simple formula is made widely useful for insulation and refractory furnace materials by many laboratory determinations of the factors for these materials. Laboratory determinations have been rendered comparable by the adoption of the hot plate method of conductivity testing. Some of the actual values thus secured will be discussed in a later paragraph.

Surface temperatures are most elusive, but fortunately in this field their values may be assumed, guessed at, or roughly determined, sufficiently close to fact for securing practical and useful results from the calculating processes. The medium in contact with furnace walls is furnace gas on the heat input side and air on the output side. Both gas and air films have a strong tendency to hug the surfaces, and these films have a rather high insulating value. The common device in engineering apparatus for removing these films and thus eliminating their insulating effect, is to accelerate the gas or air streams, or otherwise agitate them so that the quiescent films will be scrubbed off of the surfaces.

Where heat transmission is the purpose of an apparatus, as in the air heater, the gas and air films must be removed in order to secure commercial efficiency of the transfer of the heat. But in refractory-plus-insulation furnace structure insulation is the object, and the films resulting from lack of high velocity or any other method of scrubbing, actually exist in practice and are of definite value as aiding in insulating.

The conductivity factors determined for refractory and insulation materials have been secured therefore under conditions of "still air" or lack of definite circulation on either face of the material tested. These factors are perfectly suitable for heat transmission calculations for such furnace materials, but neither they nor any analogous factors may be used for such work as the air heater heat transfer problem.

These conductivity factors are determined at no difference in pressure at either face of the material. If, in an operating furnace, there is practically atmospheric pressure in the furnace, the calculated results will apply closely. If there is a material suction or pressure, however, allowance for a change in the rate of heat flow may be made when interpreting the calculated results. There is no reliable data for such interpretation; it must therefore be a matter of individual judgment.

Many refractory and insulating materials are porous. Obviously a difference in pressure on the two sides of a porous material will have greater effect as porosity increases. Porosity also increases heat flow by convection, since the gas or air in

the porosities actually circulates and carries heat from the hotter parts to the cooler.

Workmanship may result in practical porosity. That is, if the joints between units of refractory or insulation are reasonably tight, the equivalent porosity will be low; if they are loose, it will be high.

These items are thus briefly reviewed to indicate the practical modifications that may at times have to be applied to calculations which in themselves might be carried out to any number of decimal places. The calculations will approximate actual conditions sufficiently close for most practical purposes, but must not be taken too literally. A careless brick mason can cause plenty of modification to calculated results, as can an operator who piles up a heavy plus pressure in his furnace.

The curve of specific conductivity for firebrick has long been published in various works as a straight line having a value of 6.0 B.t.u. at 200 deg. fahr. mean temperature, and 12.0 at 2800 deg. fahr. But in the Bureau of Mines Bulletin 334, published in 1931, on page 66, the authors refer to tests by F. H. Norton on the thermal conductivity of firebrick as "most reliable and complete for domestic materials at high temperatures." Among these tests are one for Missouri clay brick and one for Pennsylvania clay brick. These are plotted in Fig. 1.

The old straight line curve of conductivity values above referred to is also shown in Fig. 1. Since the older straight line curve has a lower average value than those determined by Norton, it has seemed advisable to plot a new curve which averages those for the Missouri and Pennsylvania firebrick. This new curve may confidently be used as representing the thermal conductivity of the present-day average run of high grade standard firebrick and other shapes of the same material.

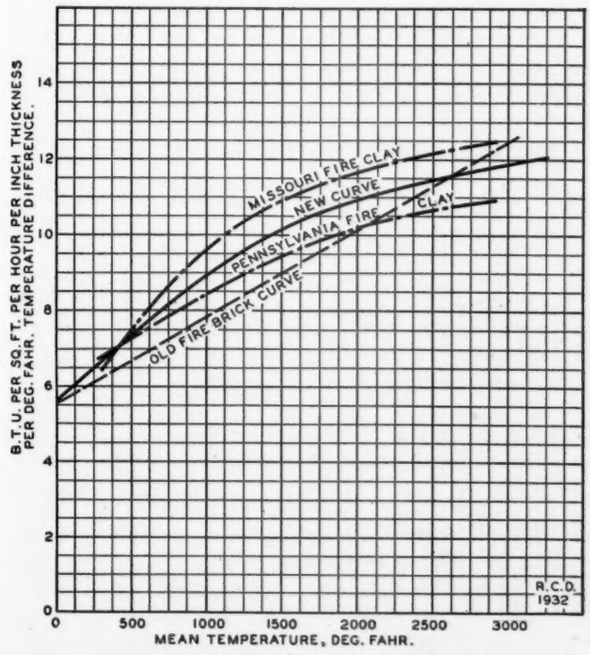


Fig. 1—Curves of specific conductivity.

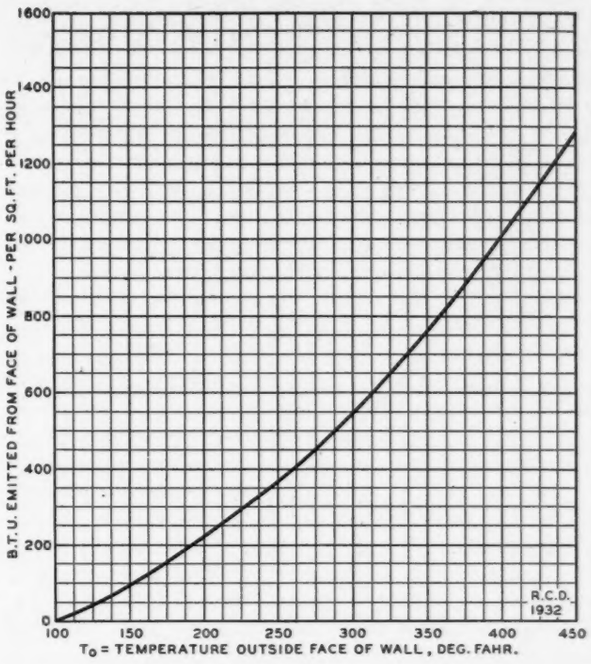


Fig. 2—Emissivity—room temperature (T_a) = 100 deg. fahr.

This new curve is used in all the calculations that follow.

The specific conductivity, or conductivity factor, is the number of B.t.u. transmitted through a material per square foot of surface area per hour per inch thickness of material per degree fahrenheit of temperature difference between hot and cold surfaces. It is customarily plotted against the mean temperature of the heat transmitting material, as done in Fig. 1. There is thus available the variable values for the factor C of equation (1) for solid firebrick walls. The other values would be known or assumed in any given case.

Emissivity is the term applied to the rate at which heat is emitted from a hot surface. The surface temperature must be higher than that of the surrounding air in order for heat to flow. The difference between these two temperatures affects the rate of heat flow, as does also the velocity of the air circulating past the face of the emitting surface. This velocity, from natural circulation past the outside surface of furnace walls, is not sufficient to affect the values for emissivity computed by equation (2). Convection and radiation are both covered by this formula, which takes the form of:

Equation (2)

$$H = .155\left[\left(\frac{T_o + 460}{100}\right)^4 - \left(\frac{T_a + 460}{100}\right)^4\right] + .25(T_o - T_a)\,5/4$$

in which H is the total heat emitted per square foot of surface per hour, T_o is the temperature of the cold face of the furnace wall (the surface emitting heat), and T_a is the temperature of the surrounding air, both temperatures in degrees fahrenheit.

The value of H in equation (2) depends in part on the room temperature. In order to facilitate comparative calculations by as many short cuts as seemed permissible, a value for T_a has been taken at 100 deg. fahr., and the equation solved for a series of face temperatures so that a curve of emissivity values would be available for solving the average problem. 100 deg. fahr., then, in the work that follows represents the average temperature of the air, not necessarily throughout the boiler or furnace room, but in the immediate vicinity of the furnace. This checks fairly well with some rough measurements in the field. A finer distinction as to room temperature is an unnecessary refinement for the average problem. The curve of these emissivity values is plotted in Fig. 2.

There have now been described sufficient formulas and curves for solving a problem of heat flow through a solid refractory furnace wall of standard firebrick. A conventional temperature gradient diagram, Fig. 3, will serve to assemble the various items in picture form. The hot face temperature is labeled T_i, the cold face is T_o, and the room temperature is T_a.

Furnace temperature is represented by T, which is invariably higher than T_i. The spread between these temperatures is dependent upon the hot gas circulation in the furnace. If the furnace in question is considered as crowded, with a high combustion rate, so that there is likelihood of the hot face of the wall being actually swept by the rapidly moving gases, then the spread may be very low, and may be assumed at zero. But if the furnace is roomy, and the duty is low, so that the stream of combustion gases do not contact the wall, there may be from 100 to 400 deg. fahr. spread between T and T_i. Here again judgment must be used in assigning a value to T_i. The possibility of error in judgment is of much greater weight in the result than the roughness of the mathematics used, so that the mathematics are of sufficient accuracy for practical work.

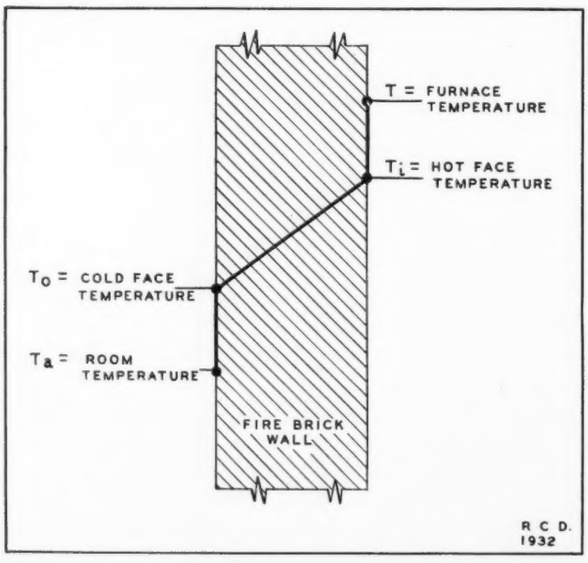


Fig. 3—Temperature gradient diagram for firebrick wall.

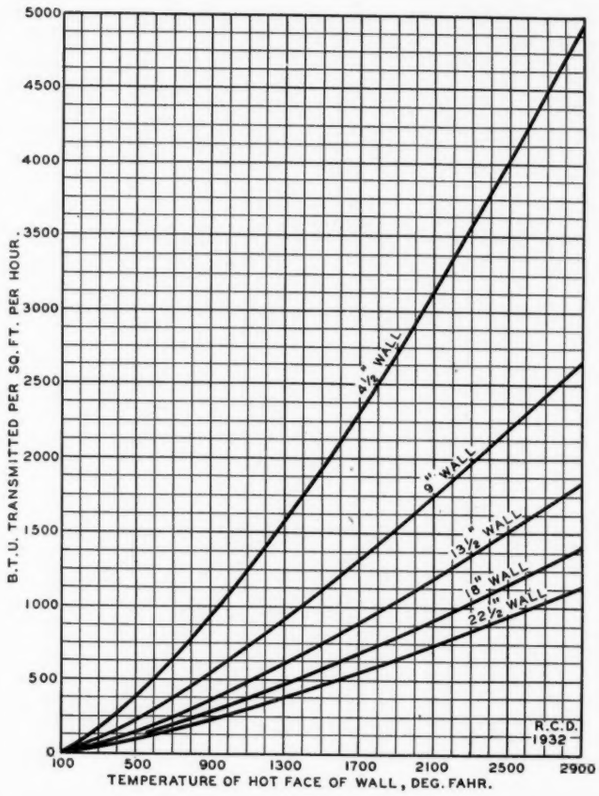


Fig. 4—Heat transmission through solid firebrick at 100 deg. fahr. room temperature.

The drop between T_o and T_a is a definite function of the heat emitted, and is not subject to judgment, except in assuming a value for T_a.

A calculation for a solid firebrick furnace wall follows. Assume T_i = 2000 deg. fahr., and the wall thickness to be 22½ in. (T_a is assumed to be 100 deg. fahr.) Solution is secured by solving equations (1) and (2) simultaneously with an assumed value for T_o that will give identical values for H in each equation. Stated from the other view point, the heat passing through the wall must equal the heat emitted from its surface. For example, assume T_o = 335 deg. fahr. and substitute this and the previously stated values in equation (1),

$$H = \frac{C(2000 - 335)}{22.5}$$

The value for C is taken from the curve of conductivity for standard firebrick, Fig. 1, for a mean temperature of

$$\frac{2000 + 335}{2} = 1168$$

and is seen to be 9.4, which is now substituted for C, giving the following,

$$H = \frac{9.4(2000 - 335)}{22.5} = 696 \text{ B.t.u.}$$

To solve equation (2) use the curve of Fig. 2 as

a short cut. The B.t.u. corresponding to 335 deg. fahr, face temperature is 695 B.t.u., which checks with the value of H from equation (1). Thus 335 deg. fahr. for T_o satisfies both equations for identical values of H.

Of course, the trick is in guessing the correct value for T_o. But this is not a very onerous procedure after one gets the hang of the variables. A second trial will often hit the nail on the head, and a third trial is almost certain to.

Since solid firebrick walls have just this one standard set of solutions for practical conditions, curves may be made up for various standard thicknesses, and a group of these is given in Fig. 4. The important point to bear in mind is the origin of the specific conductivity factors, and the standardized room temperature. These are the points on which there has not been any standard or agreed-upon basis among engineers.

The conductively curve developed seems to meet the requirements of accuracy for the average run of standard firebrick, and the room temperature assumption seems warranted by the facts of average practical furnace conditions. Such exceptions as may be taken to the origin of the above data, or to the methods of solving this heat transmission problem, are not likely to alter materially the results that are summarized in the curves of Fig. 4. These curves of heat transmission may therefore be considered of practical value, and may be used with confidence.

The American Society of Mechanical Engineers Nominates Officers for 1933

Nominations for officers of The American Society of Mechanical Engineers for 1933 were announced at a recent meeting of the Nominating Committee, held at Bigwin, Ontario, during the Semi-Annual Meeting. Election will be held by letter ballot of the entire membership, closing on September 27, 1932.

The nominees as presented by the Nominating Committee of the Society are as follows:

President—A. A. Potter, Dean, Schools of Engineering, Purdue University, Lafayette, Ind.

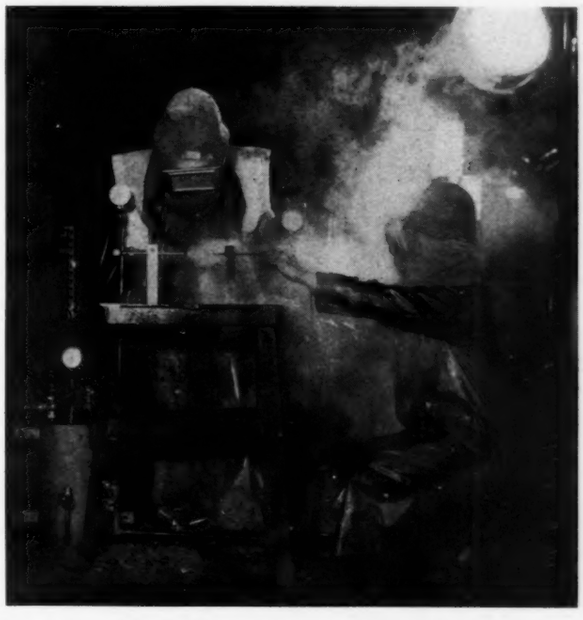
Vice-Presidents—H. V. Coes, Consulting Management Engineer, Ford, Bacon & Davis, Inc., New York, N. Y.; James D. Cunningham, President, Republic Flow Meters Corporation, Chicago, Ill.; C. F. Hirshfeld, Chief of Research Department, Detroit Edison Company, Detroit, Mich.

Managers—R. L. Sackett, Dean of Engineering, Pennsylvania State College, State College, Pa.; Alexander D. Bailey, Superintendent Generating Stations, Commonwealth Edison Company, Chicago, Ill.; John A. Hunter, Professor of Mechanical Engineering, Boulder, Colo.

Single Oil Globule Broken into 100,000,000 Particles

The breakdown of a single globule of ordinary furnace oil, no bigger than the head of a safety match, into more than 100,000,000 particles has been achieved through a new development in the General Electric laboratories. The oil, under pressure, is brought into a direct head-on impact with air under approximately the same pressure, causing superfine atomization and facilitating easy conversion of the small particles into a gaseous hydro-carbon by heat. This enables the entire energy of the fuel to be converted into heat without any loss of carbon in soot or smoke, and without excessive combustion air. This new principle is described as "progressive impact combustion," and laboratory application indicates a much more economical employment of oil as a fuel for heating purposes.

Delegated five years ago to study the electrical control of oil combustion, engineers of the General Electric Company have made hundreds of experiments in combustion, ending with the so-called laboratory battle between oil and air, under pressure, with one man holding the oil nozzle and another directing the air hose, which resulted in the new development.



Bringing oil and air into direct collision.

In the application of this principle the complete combustion of oil occurs progressively in three stages. The first, the head-on collision of oil and air under pressure, breaks up each drop of oil into millions of particles. Then follows the application of heat, which further breaks down the oil particles into gaseous hydro-carbon. The third and last stage is the collision of the gaseous hydro-carbon with the air for combustion to produce, finally, the proper and complete air-oil mixture for effective combustion.

The Atmos Revolving Tube Boiler

By
DAVID BROWNLIE
LONDON

This month Mr. Brownlie presents a complete history of the Atmos Revolving Tube Boiler. While numerous descriptions of the earlier designs of this boiler have appeared in the technical press there has been little published information concerning the present design which represents quite a departure from the early types. Mr. Brownlie describes the design and operation of the Atmos boiler from the earlier conceptions up to and including the latest development.

IN the field of modern steam and power plant practice represented by the use of steam generators that are a complete departure from what may be termed the conventional drum type of water tube boiler, the name of J. Victor Blomquist, of the Aktiebolaget Atmos, Stockholm, is well known. His Atmos revolving tube boiler originated about seventeen years ago, but the design was altered very considerably in 1928 and development work is still proceeding.

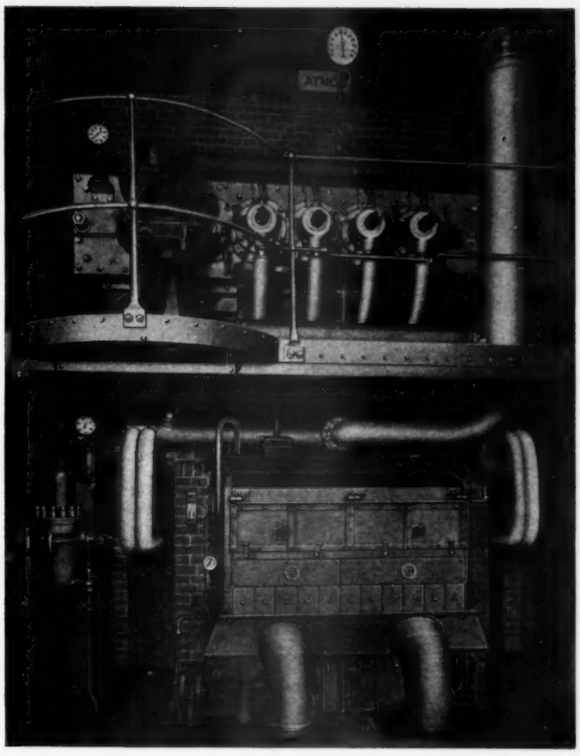
In general the Atmos boiler is intended for super-pressures such as 1400 to 1600 lb. per sq. in. gage, although the complete range is generally given as 850 to 1850 lb. with say 800 to 950 deg. fahr. superheated steam temperature. The firing can be by means of gaseous, liquid, or solid fuel, particularly pulverized fuel, oil, natural gas, coke oven gas, and blast furnace gas. One standard method of operation for power stations is in conjunction with small, high-speed, back-pressure turbines, taking the full boiler pressure of say 1400 to 1600 lb. per sq. in., and exhausting at any desired figure to the existing mains of the station.

Like a number of other inventors, Blomquist realized the inherent disadvantages of the forged-drum, water-tube boiler for, say 900 to 1800 lb. per sq. in. pressure, particularly the great weight, capital cost, and unequal heat stresses. If, however, steam is generated merely in a series of tubes without drums, which represents a relatively cheap construction of light weight, the inherent disadvantage is ebullition, the fact that small particles of water are converted into relatively very large bubbles of steam. To avoid this difficulty Victor Blomquist adopted the ingenious principle of generating steam in horizontal, comparatively wide diameter, steel tubes or rotors, driven continuously at a high speed of about 320 r.p.m. in the combustion chamber, using distilled water for the feed. By this means the resulting centrifugal force is utilized to keep a layer of water all round the inside of the rotary tube, pressed tightly up against the heated surface, in spite of the steam bubbles, giving a high rate of heat transmission, and therefore steam generation.

The results were most promising, and a number of boilers operating on these lines were placed in operation. But recently there has been adopted a different principle, what is known as the "squirrel cage rotor." Essentially this consists of a series of parallel horizontal tubes, 4¼ in. dia., attached to a circular plate at each end, in which steam is generated, the whole arrangement being driven at the slow speed of about 20 r.p.m. in the combustion chamber. Under these conditions centrifugal force plays little part in the action, but the evaporation takes place under very favorable circumstances, mainly in each individual horizontal tube while traveling round in the upper half of the setting.

The first experimental Atmos squirrel cage rotor of this new type, having a capacity of about 7700 lb. of steam per hr., was started up in 1928 to the designs of Victor Blomquist at the works of the Société Alsacienne de Constructions Mecaniques at Mulhouse in France. Excellent results were obtained, and in 1929 a second squirrel cage rotor boiler was erected with a capacity of from 22040 to 26448 lb. of steam per hr. and this has since continued in full operation. Also towards the end of 1931 a squirrel cage rotor boiler was installed at the Swedish paper mill at the Aktiebolaget Fors Bruk.

The original experimental Atmos high speed revolving tube boiler was constructed in Sweden by J. Victor Blomquist in 1915, being designed for a working pressure of from 735 to 882 lb. per sq. in. and having one simple steel tube rotor of 12 in. outside dia. with an effective length, exposed to the combustion gases in the furnace, of 8 ft. 2 in. This rotor was driven at 320 r.p.m., operating in a hand-fired brick setting, provided at the top with a superheater and also a feedwater heater. Good results were obtained, the only difficulty being that in the original design the water layer was not uni-



Atmos boiler of the high-speed-rotor type, designed for 1470 lb. per sq. in. pressure as installed at the Fors Bruk paper mill in Sweden in 1926. The upper part of the photograph shows the water inlet end of the 4 rotors.

form round the whole of the inside of the rotating tube and it was therefore necessary to add to the design a series of internal guides.

What may be termed the first large-scale Atmos high speed revolving tube boiler, although of an experimental character, was erected at the Carnegie Sugar refinery at Gothenburg (Sweden), having six rotor tubes operating within a range of 700 to 800 lb. per sq. in. pressure. This boiler had an average duty of 6613 lb. evaporation per hour, the feedwater being supplied from an ordinary water tube boiler of the drum type, at 117 lb. per sq. in., through which passed the waste combustion gases from the Atmos boiler, a superheater also being installed in the space between the two units. The steam from the Atmos boiler was used to operate a De Laval high-speed, back-pressure steam turbine running under normal conditions of 735 lb. per sq. in. at the stop valve, and 36 lb. per sq. in. back pressure.

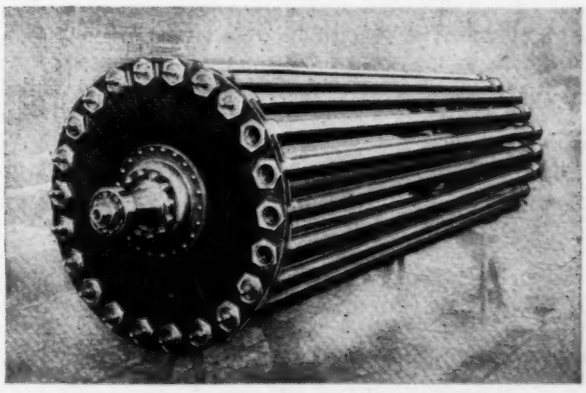
This operated for about two years and gave entire satisfaction. Consequently a second Atmos boiler was erected at the same sugar refinery for 1470 lb. per sq. in. pressure having four rotors, running as usual at 320 r.p.m. The effective length in the furnace is 11 ft. 2 in., the outside diameter 12.1 in., and the thickness of the steel shell 0.66 in., while the setting includes an economizer arranged with flues at both sides of the setting and a superheater over the top.

Then in 1926 another Atmos high speed revolving tube boiler of the same size and pressure, was erected at the Fors Bruk paper mill in Sweden. In this case, however, the economizer and the superheater were arranged over the top of the rotors. The boiler is fired with coal by means of a multiple retort stoker at the front of the setting in combination with sawdust fired by means of a special furnace arrangement at the back end, while the feedwater is pure condensed steam from the pulp dryers.

This boiler was started up in December 1926 and operated with a normal evaporation of 9038 lb. However, more steam was afterwards required so that in October 1931 the boiler was completely revamped, the four rotors being taken out and replaced by the new slow speed large squirrel cage tube rotor running at 20 r.p.m. while also the economizer and the superheater were increased in size. As the result of these changes, the output has been raised to 13,227 lb. of steam per hr., with an overload up to 15,432 lb. while the efficiency of the boiler on detailed official tests is 81 per cent, a very good result for such a small installation without air heaters.

The new standard Atmos slow-speed, squirrel-cage rotor has a maximum duty of 33,060 lb. of water evaporated per hour at say 1470 lb. per sq. in. pressure, and an installation of any desired output may be obtained by placing the desired number of identical and interchangeable squirrel-cage rotors side by side, in a combustion chamber of the necessary size.

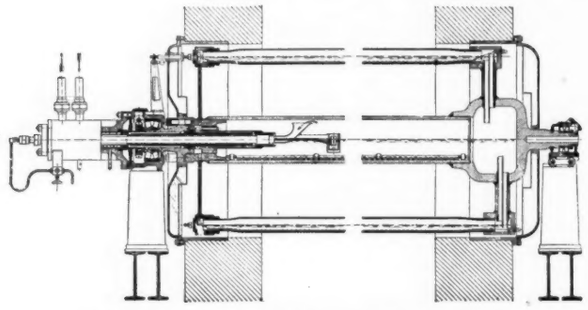
In general these rotors comprise a large central horizontal tube, cylinder, or drum of comparatively wide diameter, acting as a water reservoir, attached by transverse pipes at each end to a series of outer parallel 4¼ in. dia. tubes, up to 34 in number according to the steam output required, forming the outside of the cage, in which the water is evaporated to steam. The whole arrangement is carried by large roller bearings at each end, and driven by gearing at a speed of about 20 r.p.m. Also the water from the feed pump flows in at one end through the bearing, along the wide diameter central tube, and passes down into each of the smaller-diameter horizontal tubes which at any given moment are below the water level, about the center of the setting. Expansion and contraction of the squirrel cage makes no difference, as one of the bearings is running on rollers, and operation



New Atmos standard squirrel cage rotor.

with superheater, economizer, and air heater is carried out as usual.

In addition both the central wide diameter tube and the outer smaller diameter tubes are fitted with



Longitudinal section of Atmos squirrel cage rotor.

a special type of interior loose scraping chain, which prevents the deposition of scale, a vital point in connection with the success of the boiler, enabling ordinary softened feedwater to be used.

Explaining now the construction of the squirrel cage rotor in more detail, at the feed end of the setting are a series of narrow transverse tubes connecting the outer ring of horizontal tubes with the wide-diameter central tube or drum while at the opposite end are connecting tubes of larger diameter. These latter are divided vertically by an internal plate or partition which projects to a certain degree into the corresponding longitudinal tube and also the central tube or drum. As a result the horizontal tubes are always kept filled with water to near the center since the water can only pass out over this projection or baffle.

Under the conditions of a speed of 20 r.p.m. for the squirrel-cage rotor (1 revolution in 2.7 sec.) the actual period of evaporation in each longitudinal tube is about 1.5 sec., this action only taking place to any appreciable degree when each individual tube is in the upper half of the rotary motion of the cage. Consequently because of the very short period of evaporation the water level in each longitudinal tube is only lowered a fraction of a millimeter.

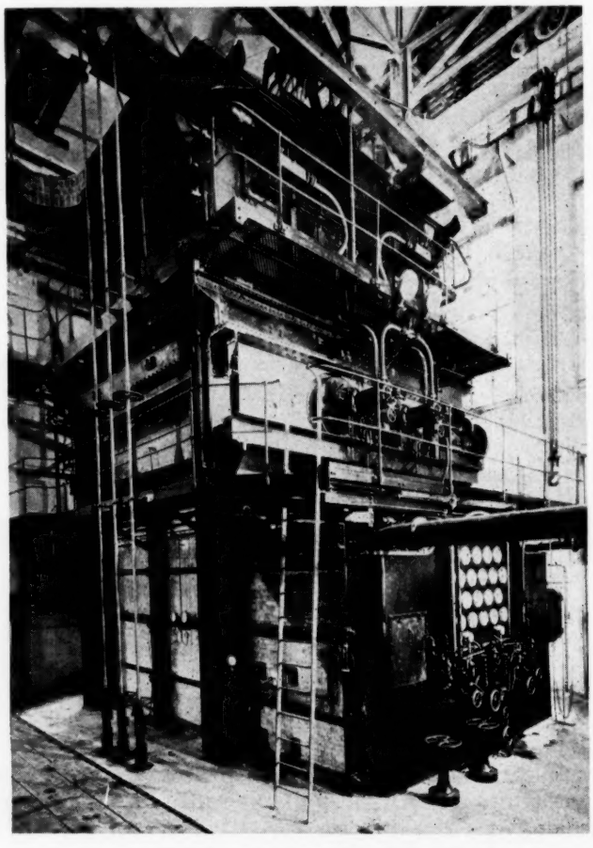
It is claimed this evaporation to steam takes place in the longitudinal rotary tubes under the most favorable circumstances. Because of the high pressure the steam bubbles are very small and they have only to break through a water layer in each tube which varies in depth from zero (at the edge) to a maximum of about 1.77 in. Consequently, the steam generated in the upper position is very dry and enters the large central tube, to which it has absolutely unrestricted passage, in this condition. At the same time the relatively small amount of steam generated in the horizontal tubes in their lower position passes up into the central tube on the other side of the central partition in the transverse, wider-diameter, connecting tubes. This steam also has good quality as regards dryness.

When the outer horizontal tubes in the course of their rotation are below the center line of the rotor there is an ample and positive flow of water from the central tube or drum through the transverse connecting tubes to the outer longitudinal tubes and back to the central tube.

The total water content of the entire rotor is as large as that of the drums of the ordinary water tube boiler. The actual temperature of any portion of the metal is relatively low.

The primary reasons why this new squirrel cage rotor construction running at about 20 r.p.m. has been adopted instead of the simple, high-speed rotor tubes of 320 r.p.m. are cheaper capital cost, and no necessity to use pure distilled water for the feed.

The present installation of the squirrel cage boiler in the boiler house of Société Alsacienne de Constructions Mecaniques at Mulhouse, which firm has the license to manufacture the boiler for the whole world except Sweden, Norway, Denmark, and Finland, where it is supplied by the Aktiebolaget Atmos of Stockholm, is composed of two of the standard squirrel cage tube rotors and operates at a pressure of 1564.5 lb. per sq. in. with superheating to 842 deg. fahr., and a normal duty under easy working conditions of 22,040 to 30,856 lb. evaporation per hr. The super-pressure steam is all used to supply a small back-pressure turbine of 750 kw. which exhausts at 176 lb. per sq. in. to the ordinary steam pipe circuits of the Mulhouse factory. The boiler is fired with pulverized coal,



Atmos boiler of squirrel cage rotor type as installed at Mulhouse, France, for conditions of 1564 lb. per sq. in. pressure, 800 deg. fahr. total steam temperature.

using a unit pulverizer with two burners, as well as an auxiliary oil burner for starting up. The feedwater is condensate.

In this connection it was found that the condensed water still gave a small amount of scale, presumably from salts carried over with the steam, along with traces of oil. Consequently, the tubes were fitted inside with the series of loose scraping chains, which has completely prevented the trouble. It was because of this result that chains are now included in the standard Atmos design.

For the feedwater two separate pumps are fitted, one of which is electric driven and the other steam driven. The latter is in reserve, but is always kept moving slowly so that it can be put into service instantly in case of the failure of the electric pump, a vital matter with a boiler of this type containing an extremely small amount of water in the circuit at any given moment.

As regards dimensions, in the squirrel cage rotor at the Fors Bruk mill the large central tube or drum is 12 in. outside diameter with 0.66 in. walls. The outer horizontal evaporating tubes are 4¼ in. O. D. and 0.31 in. thick. The dimensions vary of course; for example, in a rotor with a capacity of 22,040 to 26,448 lb. of steam per hour the central tube would be 15.6 in. with a wall thickness of 0.98 in., the number of the longitudinal tubes being 28 and the effective length 13 ft. 1 in.

One of the main advantages claimed for the Atmos boiler is the great rapidity with which it can be started up and closed down. For example, in this plant at Mulhouse when the boiler is absolutely cold the full duty of the turbine 750 kw., with a steam pressure of 1470 lb. per sq. in. at the stop valve, is obtained in 25 min. Thus about 8 min. from starting the auxiliary oil burner to light up the pulverized fuel burners the steam pressure of the boiler is 955 lb. per sq. in., and steam is already being passed to warm up the high pressure turbine, which is put into actual running about 14 min. from the time of starting, and attaining full output. Similarly the boiler can be closed down completely in 20 min., the coal, feedwater, and draft being shut off but the water allowed to circulate through the boiler for the above period until the brickwork is sufficiently cooled, when the supply of water is stopped.

Other advantages claimed are a high rate of evaporation of 61.5 lb. per sq. ft. of heating surface, per hour, little or no priming, absolutely uniform stress in the tubes, and small weight per unit of evaporation.

The Société Alsacienne de Constructions Mecanoques at Mulhouse have published full details of the design of a large Atmos power station boiler plant with a normal evaporation of 165,300 lb., per hr., and 198,360 lb. overload. This consists of 6 of the standard squirrel cage rotors side by side, each driven by gearing at 20 r.p.m., operating in a combustion chamber having over the top in series a high-pressure superheater, low-pressure superheaters, steaming economizer, and ordinary economizer, the final waste gases being taken from the top of the setting by induced draft fans and discharged to the chimney at very low temperature.

Finally it may be stated the latest design of the Atmos boiler, which has not yet reached commercial operation comprises a squirrel cage rotor of very large size, with a calculated capacity of 110,-200 lb. of water evaporated per hr., and with combustion taking place actually within the rotor. That is the rotor tubes themselves form the walls of the combustion chamber, the object being to reduce still further wear and tear on the firebrick.

In writing this description I have to express my sincere thanks to Mr. Victor Blomquist of Stockholm for kindly supplying illustrations and much detailed information.

New Law on Professional Engineering Licenses in New York

On March 28, 1932, a law went into force in New York, making more stringent the requirements to obtain a license to practice as a professional engineer. The provisions of this law are as follows:

For a license as a professional engineer, evidence must be submitted that the applicant: (1) is more than 25 years of age; (2) is a citizen of the United States, or has legally declared his intention of becoming a citizen; (3) is of good moral character; (4) has satisfactorily completed an approved four-year high school course, or the equivalent thereof; (5) has had eight years or more of practical experience in professional engineering work of a grade and character satisfactory to the examiners; (6) has passed the prescribed examinations.

The department, on the recommendation of the board of engineers, may waive qualifications four, five or six, above mentioned, in the cases of applicants who are possessed of long-established and recognized standing in the engineering profession and who have practiced lawfully for more than twelve years or who were actively engaged in the practice of professional engineering for at least four years prior to May 14, 1920.

The applicants who cannot qualify under the provisions of the preceding paragraph must take an examination and establish among other things their competency to plan, structurally design and supervise the construction of buildings, and similar structures. Each written examination may be supplemented by such oral examination as the department shall determine upon recommendation of the board. Examinations are held twice each year in at least three convenient places in the state. The fee for a license as a professional engineer continues to be $25.00.

Every person applying for a license subsequent to January 1, 1937, shall be required to pass the examination and before admission thereto shall submit evidence that he has graduated from a college or school of engineering registered as maintaining satisfactory standards.

NEW CATALOGS AND BULLETINS

Any of the following publications will be sent to you upon request. Address your request direct to the manufacturer and mention COMBUSTION Magazine

Centrifugal Pumps

Bulletin 1650 describes the Type "S" Centrifugal Pumps which are applicable to general purposes. The Type "S" centrifugal pump is a single stage, double suction pump, designed for pumping liquids against heads up to 300 ft. and in some special cases higher. The bulletin is generously illustrated with photographic reproductions and drawings. Tables giving the various limitations are included. 32 pages, 8½ x 11—Allis-Chalmers, Milwaukee, Wisconsin.

Coal Pulverizer

A new catalog has been recently published entitled Riley Atrita Unit Pulverizers. The operation of the various elements in the pulverizer is described and the details of the several stages of pulverizations are set forth. The catalog is profusely illustrated with photographic reproductions. 16 pages, 8½ x 11—Riley Stoker Corporation, Worcester, Mass.

Exhaust Washer and Silencer

A folder has been just issued describing the Model EW corrosion-proof Maxim Exhaust Washer and Silencer. This device quenches all sparks, washes the exhaust clean of all carbon and dirt, quiets the exhaust noise just as much as the standard dry-type Maxim exhaust silencers and at the same time does not impose sufficient back pressure to affect the operating efficiency of the engine to which it is attached. The Model EW Maxim Silencer is made entirely of cast iron and hence practically corrosion proof. 4 pages 8½ x 11—The Maxim Silencer Company, Hartford, Conn.

Forged Steel Valves

Section G1 to Catalog No. 10 of the Edward Drop Forged Steel Valves has recently been issued. This folder briefly describes and illustrates the Globe and Angle Stop Valves for 600 lb. w.s.p. Dimension, weight and price tables are included, 4 pages, 8½ x 11—The Edward Valve & Manufacturing Company, East Chicago, Indiana.

Gas and Oil Burners

Forney Gas and Oil Burners for Power Plant and Industrial Uses—is the name of a catalog recently issued.

The principle of operation of this burner is as follows: The gases as well as the oil leaves the burner tip from a central point in the shape of a cone at a wide angle to the entering air. This provides a turbulent mixing of the fuel and air. Complete combustion is obtained with a minimum of excess air and without the aid of refractory blocks or fronts. Combustion is quickly effected in a short flame impingement on the furnace walls and an even heat distribution is obtained in the furnace. 16 pages, 8½ x 11—Forney Combustion Engineering Company, 513 Central Bank Building, Dallas, Texas.

Governors

A folder has been just published describing and illustrating the new Copes Type 505-2 Governor. This governor controls within close limits any excess pressure from 15 to 50 lb. It can be installed on simplex or duplex pumps, and on turbine or motor-driven centrifugal pumps. It is suited for excess pressure service in boiler feeding; differential reducing valve service on motor-driven centrifugal pumps; and for constant pressure service up to 150 lb. 4 pages, 8½ x 11—Northern Equipment Company, Erie, Penna.

Hydraulic Couplings

A folder has recently been issued describing Hydraulic Couplings Model FD. These couplings are generally applied to installations using a constant speed squirrel cage motor as the driver, and function as a direct driving medium between the motor and the fan. There is no mechanical connection between the driver and the driven halves of the coupling. Power is transmitted by the kinetic energy of the liquid discharged by the impeller directly against the vanes of the runner. There are no packed joints or high pressure fittings on the unit. 4 pages, 8½ x 11—Hydraulic Couplings, Inc., Detroit, Michigan.

Lock Nuts

A pamphlet has been issued describing the newly developed Dalwa Lock Nut. This nut consists of two component parts assembled into a single working unit—a nut proper, and an elastic steel compensator. The nut on the seating face is provided with a conical groove containing a ring which is divided into four equal segments by slots. The compensator is an elastic steel washer shaped to fit into the groove of the nut. The principles of operation are outlined in detail. 4 pages, 8½ x 11—International Safety Lock Nut Corporation, 67 Broad Street, New York, New York.

Oil Burners

A new catalog has been published describing the Schutte & Koerting Mechanical Fuel Oil Burner Type C. In this burner the atomization is produced mechanically without the use of pressure air or live steam. The oil is forced under pressure through a nozzle of the spiral type, discharging into the furnace in the shape of a finely divided spray, which is readily mixed with the combustion air. This oil burner is designed for use on standard boilers and in industrial furnaces of various kinds. 20 pages, 8½ x 11—Schutte & Koerting Co., Philadelphia.

Refractory

A folder has been issued describing Laclede Mullite firebricks. Mullite is a stable crystalline combination of silica and alumina. Mullite crystals are highly refractory and their presence in any refractory material is therefore most desirable. It is claimed that Laclede Mullite is non-spalling, i.e., it is not affected by temperature changes at all; that it neither shrinks or expands permanently when subjected to very high temperatures for long periods; that it is resistant to slag action and has a high load bearing capacity. 4 pages, 8½ x 11—Laclede-Christy, St. Louis, Mo.

Smoke Abatement

A bulletin, recently issued by the Anthracite Institute, contains reprints of a series of articles which appeared in the World-Telegram and radio speeches which were delivered during the course of a smoke abatement campaign conducted by the Institute. The radio speeches were delivered by the following authorities on the subject:—Colonel E. H. Whitlock, Prof. H. H. Sheldon and Dr. H. N. Davis. The World-Telegram articles were written by Miss Elizabeth Clark. Some very interesting photographic reproductions are included. 28 pages and cover, 8½ x 11—Anthracite Institute, 19 Rector Street, New York.

Underground Steam Lines

A catalog on underground steam-distributing systems has been issued recently. Several installations are described and illustrated. The equipment for underground steam lines are shown together with sketches including dimensions. 16 pages, 8½ x 11—Underground Steam Construction Company, 75 Pitts Street, Boston, Mass.

NOTICE

Manufacturers are requested to send copies of their new catalogs and bulletins for review on this page. Address copies of your new literature to

COMBUSTION
200 Madison Ave., New York

NEW EQUIPMENT

of interest to steam plant Engineers

Speed Reducing Gear

The De Laval Steam Turbine Company, Trenton, New Jersey, have placed on the market a new line of worm reduction gears with roller bearings on the gear shaft to supplement their previous line of worm reduction gears in which plain split sleeve bearings are used on the gear shaft.

The illustration shows a top drive unit, that is, with the worm drive on the upper side of the worm wheel. Units are also built with the worm at the bottom.

The casings or frames for these speed reducers have been designed for stiffness, strength, and to present a large surface for the dissipation of heat. The reducers in this new line are built in ratios ranging from 4 to 1 up to 1,000 to 1 in. single reductions; in double reductions, up to 8,000 to 1. Either the worm or gear shafts may be extended on either side or on both sides, if required.

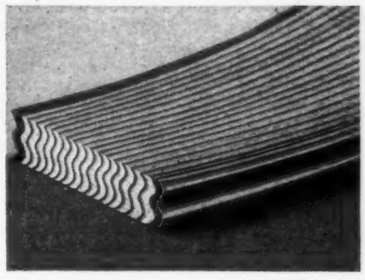
De Laval worm reduction gears differ from ordinary worm gears in general

design, in the tooth shape used, in the materials used and their treatment, in the manufacturing methods and shop control. The tooth shape is such as to combine a maximum rolling and a minimum of sliding action between the worm and the gear and, at the same time, to realize continuously the greatest possible area of contact. The included angle of the tooth is approximately 60 deg., as compared with about 30 deg. as used in older designs thus undercutting is entirely eliminated. The bearings and similar parts are made on an interchangeable, limit gage basis throughout and the shafts are ground to the proper tolerances for pressed fits.

Gaskets

The Garlock Packing Company, Palmyra, N. Y., has recently developed a type of gasket known as the Guardian gasket for which the following claims are made: 1. Safe against any pressure or temperature. 2. Resists gases and liquids. 3. Joints remain tight under changing temperatures. 4. Retains its resiliency in service.

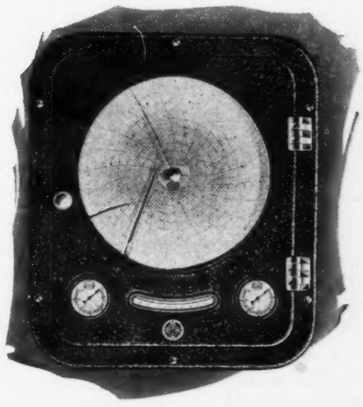
This gasket is designed for service on boilers, pipe lines or other equipment subject to frequent or rapid temperature



changes or on jobs where vibration is encountered. The construction of the gasket is such that it serves in the capacity of an expansion joint, adjusting itself, without leakage, to the expansion and contraction of the joint. The tightening of the gasket in the joint does not destroy the compression and rebound qualities which it possesses.

Recording Temperature Controller

The Mason Regulator Company of 1190 Adams Street, Boston, announce a new feature in temperature control, the Mason Recording Temperature Controller with the *Thermo-Pressure Compensator.* This Mason Controller operates on a new principle—it not only controls the temperature by throttling the supply of heating or cooling medium—but it also compensates the pressure and resultant rate-of-flow of this medium. The result is that heating or cooling medium pressure changes which would ordinarily vary the



temperature being controlled are checked before the temperature has a chance to fluctuate. This anticipatory action insures very accurate temperature control.

This new Mason Instrument has other improved features; such as the compound balanced pilot valve which causes the diaphragm control valve to always maintain a "floating" position in accordance with the operating conditions. Dual helical temperature coils provide a continuous positive check on each other. One actuates the control mechanism while the other inscribes a true chart record.

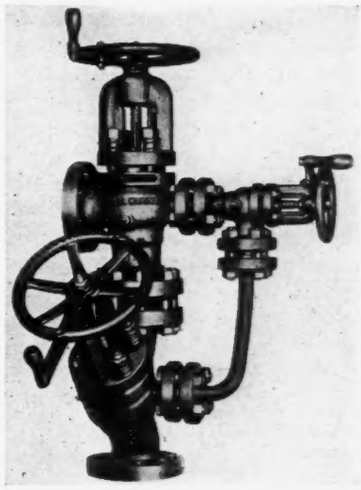
Many of the working parts of this instrument are machined from non-corrosive stainless steel and insure long, trouble-free performance.

Complete information about this new Mason Temperature Instrument may be obtained from the Mason Regulator Company.

Triplex High Pressure Blow Down Combination

The Yarnall-Waring Company Chestnut Hill, Philadelphia, have placed on the market the new Yarway Triplex High Pressure Blow Down Combination. This valve combination comprises a Yarway 2½ in. high pressure 1400 lb. angle valve, a straightway 2½ in., 1400 lb. valve and a 1 in. angle valve connected to the annular space of the first two valves.

This combination was developed to overcome the troubles, such as cracking, usually experienced when blowing down large boilers at 1400 lb. pressure through large valves. This Triplex arrangement has been designed so that the actual blowing down of the boiler under pressure is done through the 1 in. valve which is at



all times connected to the boiler by means of the annular space provided in the 2½ in. angle valve. The sequence in using this Triplex valve is first to open the 2½ in. straightway valve, then blow down with 1 in. angle valve, then close the 1 in. angle valve and finally close the 2½ in. valve. On the other hand, both 2½ in. valves are to be used when washing out the boiler.

All three valves are completely equipped with double Alemite check fittings so that the internal parts can be lubricated even under pressure. The valves are also furnished with yoke springs which maintain a constant pressure at all times upon the packing train and insure, thereby, a very long life to the packing. The stem collar in each valve is provided with double ball bearings to take the thrust of the plunger both ways. Moreover, these valves are equipped with plungers made of nitralloy which is the best material to use for this severe service.

REVIEW OF NEW TECHNICAL BOOKS

Any of the books reviewed on this page may be secured from
In-Ce-Co Publishing Corporation, 200 Madison Avenue, New York

The Nature of a Gas

By Leonard B. Loeb

THIS volume is the first of a series of monographs to be published under the auspices of the Committee on Electrical Insulation of the Division of Engineering and Industrial Research, National Research Council, with J. B. Whitehead, Dean of Engineering at Johns Hopkins University, as chairman.

Professor Loeb has been one of the first to respond to the efforts of this Committee to assemble a series of authoritative reviews on important fundamental properties of dielectric substances. Gases are utilized as insulators, and occur in insulating materials in a wide variety of conditions.

This book presents in an exceptionally clear manner the essential facts covering atomic and gaseous structure. It will serve as an excellent introduction to engineers and industrial technicians on the electrical properties of a gas as a preparation for more advanced and technical monographs on the subject. The volume is brief, concise, but gives all necessary data on the breakdown of solid and liquid dielectrics.

The book is developed in an interesting and logical manner, and is the only compilation of reliable data on electrical properties of gases. It will appeal to physicists, chemists, electrical engineers and all those who work on electrical problems in which a gas is used as an insulator or conductor, or where its presence modifies the main phenomenon.

This book contains 153 pages, size 6x9. Price $2.50.

Behemoth:

The Story of Power

By Eric Hodgins & F. Alexander Magoun

SETTING out to prove no theses and taking no sides in the quarrels centering around our machine civilization, Eric Hodgins and F. Alexander Magoun have told in BEHEMOTH: The Story of Power, the first complete story of this age of power and of its creation out of the vague and confused beginnings that followed the close of the Middle Ages. Combining vivid history and biography with sound science, Mr. Hodgins and Mr. Magoun paint a picture of the rise of power from primitive days, when muscles were the only power machines, down to the modern marvels of machinery, which cram 100,000 horsepower into the size of a modern five-room apartment.

BEHEMOTH is the story of an age, entertainingly told in terms of the men who created it: Dionysius Papin, fooling with a pressure cooker filled with jellied bones, creating before the eyes of the Royal Society the basis of the steam engine; James Watt, making that engine practical by inventing the condenser (it was Watt, too, who first used the term "horsepower"); Michael Faraday, a blacksmith's son, walking the cobblestones of a gaslit London, his mind bursting with an idea which shortly afterwards materialized in the first electric dynamo and the first electric motor. The work of these men and many more, including Potter, Van Musschenbroek, Newcomen, Volta, John Fitch and Edison, is described with gusto and humor in a book which dramatizes our world for us.

This book contains 354 pages, size 6½x9. Price $3.50.

The Quest for Power

By Hugh P. Vowles and Margaret W. Vowles

THIS book is a simple and connected account of man's endeavors throughout the ages to augment his bodily power and to turn the forces of nature to his own advantage.

The book is divided into 3 parts, the first of which is called "The Apprenticeship of Toil." In this section the story of man the tool-maker is told, then the development of craftsmanship, early structural and transport achievements, and transitions from the stone to the bronze and finally to the iron age. The second part, entitled "The Age of Power," continues the story and tells us of the earliest known experiments with steam, the origins of the water wheel and windmill, the evolution of the steam engine, the development of the water wheel into the water turbine, the origin and development of the internal combustion engine, the steam turbine and the electric generator. The third part, "The Materials of Power," is of exceptional interest, as it deals exhaustively with coal, both as to production, utilization and treatment, from the earliest times, continuing with its great rival, oil.

The book is profusely and attractively illustrated, and we believe it will have a wide appeal to engineers in many branches.

The book is cloth bound and contains 354 pages, size 5½x8½. Price $6.00.

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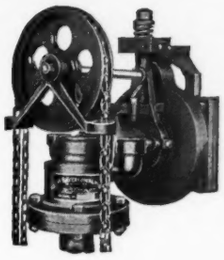

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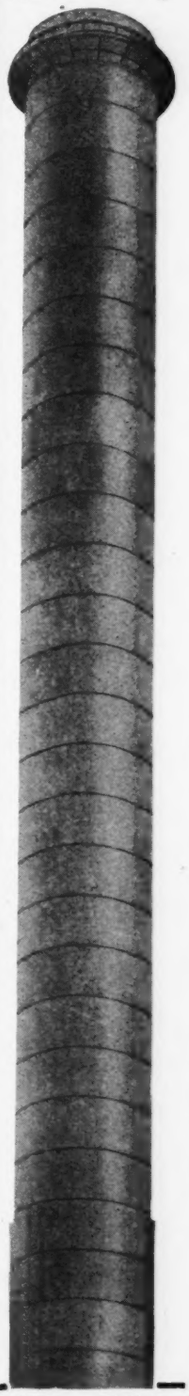

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BOOKS FOR THE ENGINEER

1—General Engineering Handbook

(First Edition)

Editor-in-Chief:
Charles Edward O'Rourke

922 pages . Price $4.00

The plan for this handbook, according to the editor-in-chief, who is Assistant Professor of Structural Engineering at Cornell University, was conceived in the belief that a great amount of fundamental engineering data could be assembled in a compact pocketbook of not over 900 pages, which would be valuable as a ready reference and hand companion for practicing engineers and for students. The purpose is to supply a compact reference work of important fundamentals for all engineers.

The author seems to have accomplished this in a most satisfactory manner. There are 31 sections, each section dealing with one general subject. Six of these sections contain material which is of importance to all engineers; others belong in the fields of civil, mechanical, electrical engineering, etc. Also engineering mathematics.

The book contains tables and charts useful in the various branches of engineering. An important factor is a bibliography of the important works dealing with the subject, at the end of each chapter. There is also a comprehensive index.

2—Science in Action

By Edward R. Weidlein
and William A. Hamor

310 pages Price $3.00

The authors, both connected with the Mellon Institute of Industrial Research, present in clear language, a sketch of the value of scientific research in American Industry. This interesting and readable book is planned to give the business man, engineer and scientist a comprehensive picture of the place of science in industry—the means and methods of industrial research, the results achieved, the important factors in procedure and the choice of workers. To the lay reader who is interested in the significance of science in modern life it offers an abundance of information authoritatively presented. Here are a few of the topics covered: groundwork of industrial research; scientific research contributions to engineering economics; industrial research in the reduction of wastage; scientific research on problems of industrial management; industrial-research laboratory management; industrial research workers.

3—Power Plant Management

By Walter N. Polakov

171 pages Price $2.00

This book offers information of considerable value to those concerned with the management or supervision of power plants, and will help to solve many problems.

Today, power plant cost comes next to payroll as an expense item in textile finishing, paper products, food industries and other enterprises. In the application of efficient methods—checking layouts, costs, waste, etc.—in the generation, distribution and utilization of power, and especially in the scientific organization of the human element, savings of tens and hundreds of thousands of dollars are possible. It is to show management's place in creating these savings—to outline the simple proceedings necessary for the typical power plant, large or small—that this book was planned.

4—Hydraulics (4th Edition, Revised 1932)

By E. H. Lewitt, B. Sc.
(London)

384 pages 8½ x 5½ Price $3.00

Deals from first principles with the theory of hydraulics and its application. This is primarily a student's textbook and no attempt has been made to deal with design problems, which are beyond the scope of the engineering degree. Numerous worked-out examples from past B. Sc. examinations of the University of London are included; also a number of exercises, with answers, at the end of each chapter. A large amount of new matter has been added to the former edition of this book, giving the results of recent researches on the viscous flow of fluids. Contains numerous illustrations and diagrams; a summary of formulas, useful tables and data. Useful in the examinations for the A. M. Inst. C. E. and the A. M. I. Mech. E.

5—The Book of Metals

By Donald Wilhelm

332 pages Price $4.00

This book is typical of several others published in recent years in that it discloses the principles and practices of a thoroughly technical industry in such form that it is just as easily assimilated by the layman as by the technician.

Mr. Wilhelm writes in a style that is as entertaining as it is informative. He takes up each metal in turn, describes the sources of supply, tells how it is taken from the ground, refined and manufactured.

This book should be read by everyone who is interested in knowing the whys and wherefores of the principal metals, and even by those who are perhaps fairly well informed in these matters but who would like to have a glimpse into the great steel laboratories of today so that they might know more of the innumerable alloys which are being developed there to meet the future needs of industry.

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